DOCUMENT RESUME

ED 316 751 CE 054 449

AUTHOR	Walden, Charles H.; Nobles, Jack
TITLE	Machine Shop. Module 3: Bench Work and Material Science. Instructor's Guide.
INSTITUTION	Missouri Univ., Columbia. Instructional Materials Lab.
SPONS AGENCY	Missouri State Dept. of Elementary and Secondary Education, Jefferson City. Div. of Vocational and Adult Education.
PUB DATE	89
NOTE	214p.; For related documents, see CE 054 447-454. Document contains colored paper. Student reference and worksheets are included in this document.
AVAILABLE FROM	Instructional Materials Laboratory, University of Missouri, 2316 Industrial Drive, Columbia, MO 65202 (order no. 70-6173-I: $21.35).
PUB TYPE	Guides - Classroom Use - Guides (For Teachers) (052)
EDRS PRICE	MF01 Plus Postage. PC Not Available from EDRS.
DESCRIPTORS	Competency Based Education; Educational Objectives; *Machinery Industry; *Machine Tool Operators; *Machine Tools; *Machinists; Measurement Equipment; Metallurgy; Occupational Information; Postsecondary Education; Secondary Education; *Tool and Die Makers; Trade and Industrial Education
IDENTIFIERS	Missouri

ABSTRACT

This document consists of materials for an 11-unit course on the following topics: (1) hacksawing; (2) filing and deburring; (3) locating centers for drilling; (4) cutting threads with tap and die; (5) using a hand reamer; (6) pedestal/bench grinder operation; (7) whetting, polishing, and lapping; (8) screw, drill, and tap extraction; (9) arbor press operations; (10) types of materials; and (11) testing and hardening materials. The instructor's guide begins with a list of competencies covered in the module, descriptions of the materials included, an explanation of how to use the materials, and information on how the curriculum guide is packaged. Next is a table that associates individual instructional materials in the units with the competencies they teach. The instructional units follow, each of which may include unit objectives, lesson objectives, lesson plans, references, notes to the teacher, information sheets or outlines, transparency masters, handouts, assignment sheets, job sheets, unit tests, and answers to tests. (CML)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

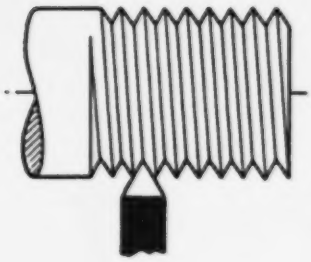
ED316751

70-6173-I

MACHINE SHOP CURRICULUM

INSTRUCTOR'S GUIDE

MODULE 3: Bench Work and Material Science



U.S. DEPARTMENT OF EDUCATION
Office of Educational Research and Improvement
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

☑ This document has been reproduced as received from the person or organization originating it.

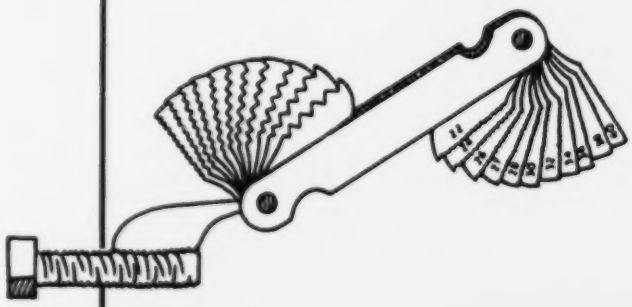
☐ Minor changes have been made to improve reproduction quality.

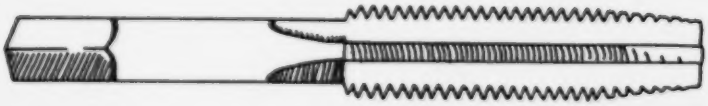
• Points of view or opinions stated in this document do not necessarily represent official OERI position or policy.

"PERMISSION TO REPRODUCE THIS MATERIAL IN MICROFICHE ONLY HAS BEEN GRANTED BY

F. Schlechter

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."





INSTRUCTIONAL MATERIALS LABORATORY • UNIVERSITY OF MISSOURI-COLUMBIA • COLUMBIA, MISSOURI

CE054449

BEST COPY AVAILABLE

Modules in this IML Machine Shop series

1: *Machine Shop Orientation and Math* by Donna Curtis and Jack Nobles
2: *Measurement and Blueprint Reading* by Charles H. Walden, Don Marquardt and Henry "Junior" Cagle
3: *Bench Work and Material Science* by Charles H. Walden and Jack Nobles
4: *Power Saw and Drill Press Operation* by Charles H. Walden and Bill Daniel
5: *Lathes* by Jack Nobles
6: *Milling* by Charles H. Walden
7: *Grinders* by Jack Nobles and Mel Gage
8: *CNC (Computerized Numerical Control)* by Dwight Crosswhite

The activity which is the subject of this report was supported in whole or in part by funds from the Department of Elementary and Secondary Education, Division of Vocational and Adult Education. However, the opinions expressed herein do not necessarily reflect the position or policies of the Missouri Department of Elementary and Secondary Education or the Division of Vocational and Adult Education, and no official endorsement should be inferred.

MACHINE SHOP

Module 3: Bench Work and Material Science

by

Charles H. Walden and Jack Nobles

Diane M. Davis, editor/project coordinator
Instructional Materials Laboratory
8 London Hall
University of Missouri-Columbia
Columbia, MO 65211

1989

Instructor's Guide
Catalog No. 70-6173-I

FOREWORD

Once again, we are indebted to the teachers and administrators who provide their time, efforts and professionalism to develop curriculum for trade, technical and industrial education programs. This Machine Shop guide is an outstanding example of what can be accomplished when the right people with the right attitude get together. Committee members worked hard over several years' time in advisory, writing, technical consultation and field-test capacities.

This guide is designed to be totally integrated with the Vocational Instructional Management System. It is hoped that all guides produced under our supervision will help classroom teachers manage instruction. A curriculum guide is more than a resource--it is an integral part of the management system. Rather than impeding instruction, it should guide and facilitate instruction.

This guide's format has been set up for competency-based teaching and testing. Unit tests evaluate specific competencies and can be used with the Vocational Administrative Management System (VAMS). Information sheets, transparency masters, job sheets, assignment sheets and test items are keyed to specific competencies. A cross-reference table has been included to quickly identify parts of the curriculum that relate to specific competencies. The material has also been packaged for students.

Although this guide may be a new format for some teachers, we are confident that, when used as designed, time spent by teachers and students will become more productive. Any future machine shop curriculum modifications will begin with this guide. The machine shop field is undergoing considerable change. We will annually evaluate the need to update this guide on a module-by-module basis. Your suggestions regarding areas for improvement are both encouraged and appreciated.

Judith Moore, supervisor
Industrial Education
Department of Elementary and Secondary Education

Charles "Chuck" Waibel, director
Industrial Education
Department of Elementary and Secondary Education

ACKNOWLEDGMENTS

This Machine Shop guide represents a continuing commitment to Missouri's Vocational Instructional Management System (VIMS). The guide has been keyed to the machine shop competency profile developed by industry and education professionals in the state.

Appreciation is given to the writers (Charlie Walden, Jack Nobles, Dwight Crosswhite, Donna Curtis, Don Marquardt, Bill Daniel, Mel Gage and Jr. Cagle) for their technical expertise. Catherine Smith of Dodge Art Works, Columbia, created a large portion of the guide's artwork.

These industry representatives and educators contributed to the guide as members of the advisory committee.

Junior Cagle, Poplar Bluff AVTS
Bill Daniel, Hannibal AVTS
Mel Gage, Linn Technical College
Pete Lopez, N.S. Hillyard AVTS, St. Joseph
Jack Nobles, McDonnell-Douglas Aircraft, St. Louis
Charlie Walden, Mechanical & Aerospace Engr., University of Missouri-Columbia
Mike Dyrenfurth, Dept. of PAVTE, University of Missouri-Columbia
Charles Waibel and Judith Moore, Division of Vocational & Adult Education, Department of Elementary and Secondary Education, Jefferson City

Educators who field-tested the guide in the classroom include the following.

Junior Cagle, Poplar Bluff AVTS
Bill Daniel, Hannibal AVTS
Charles Dawson, Moberly AVTS
Mel Gage, Linn Technical College
Pete Lopez, N.S. Hillyard AVTS, St. Joseph
David Michael, Lex La-Ray Area Vocational Technical Center, Lexington
James Newman, Jefferson College, Hillsboro
Willburn "Kirt" Salmons, State Fair Community College, Sedalia
Russell Schleiermacher, Davis H. Hart Mexico AVTS
James Shimel, Longview Community College, Lee's Summit
Coy Smith, Rolla AVTS

Support and contributions of IML staff members were instrumental to this module's development.

Harley Schlichting, director
Amon Herd, associate director
Phyllis Miller and Dan Stapleton, assistant directors
Donna Curtis and Lori Holliday, word processors
Julie Bishop, student assistant - clerical
Wei Li, graduate assistant

TABLE OF CONTENTS

Unit I: Hacksawing 1
Unit II: Filing/deburring 23
Unit III: Locating centers for drilling 53
Unit IV: Cutting threads with tap and die 73
Unit V: Using a hand reamer 111
Unit VI: Pedestal/bench grinder operation 125
Unit VII: Whetting, polishing and lapping 163
Unit VIII: Screw, drill and tap extraction 187
Unit IX: Arbor press operations 217
Unit X: Types of materials 251
Unit XI: Testing and hardening materials 267

COMPETENCIES ADDRESSED IN THIS MODULE

E. Performing Bench Work

1. Use and care of hand tools
2. Cut material with hand hack saw
3. Bench file/deburr workpiece
4. Mark locations with prick and center punches
5. Locate holes with transfer screws and transfer punches
6. Cut threads with die
7. Cut threads with hand tap
8. Ream holes with hand reamer
9. Dress and true grinding wheels on pedestal/bench grinder
10. Grind and shape tools on pedestal/bench grinder
11. Use abrasives/whetting/polishing/lapping
12. Grind using appropriate hand grinder
13. Remove damaged screws
14. Remove broken drills and taps
15. Remove and install dowel pins
16. Install a helical coil thread insert
17. Straighten workpiece on arbor press
18. Assemble and disassemble workpiece with arbor press
19. Broach workpiece with broaching tool
20. Assemble and disassemble precision parts

F. Introduction to Material Science

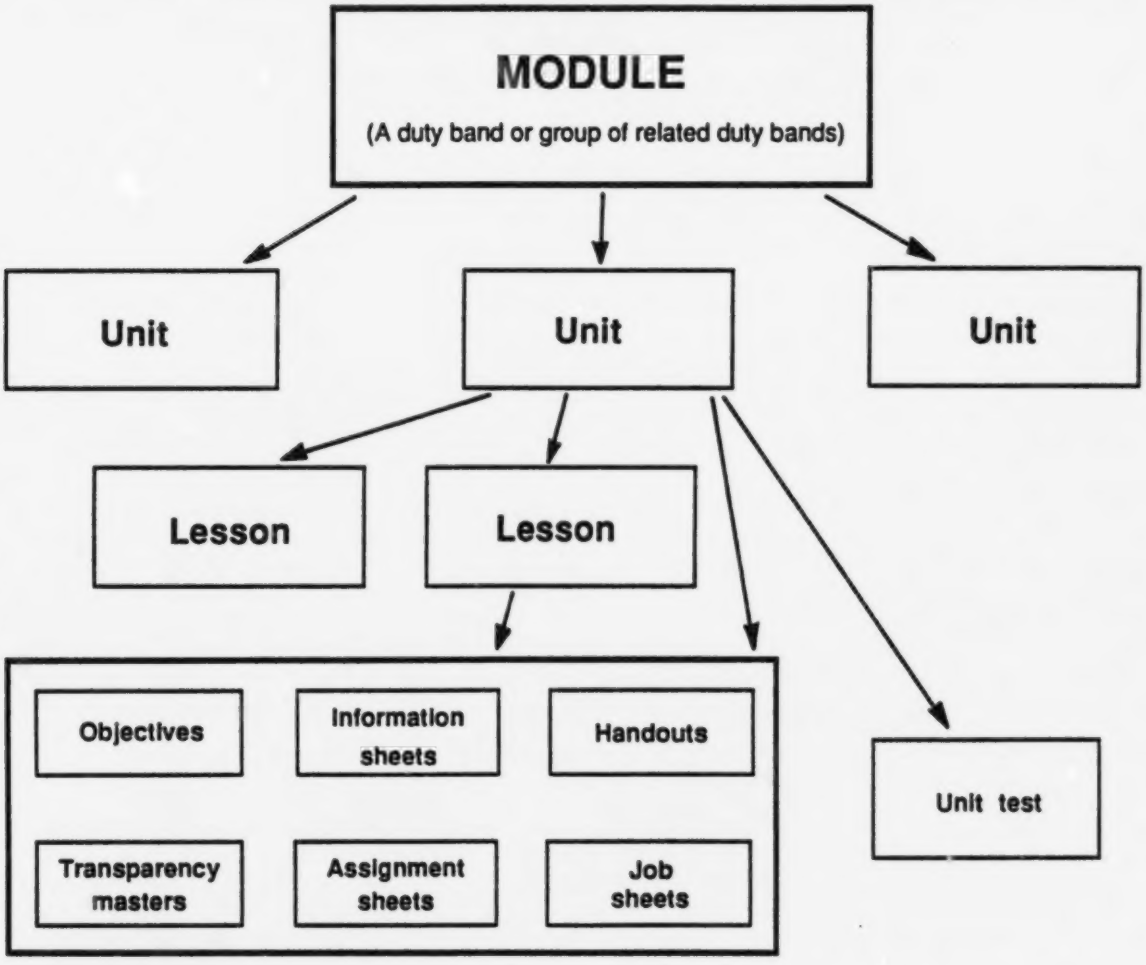
1. Identify types of metals and related materials
3. Correlate types of materials to their properties
5. Perform heat treatment process
6. Test workpiece for hardness without hardness tester

HOW TO USE THIS PUBLICATION

GUIDE COMPONENTS

Units of Instruction

This Machine Shop guide contains eight modules of instruction. Within each module are instructional units including some or all of the following components: performance objectives, information sheets, transparency masters, handouts, assignment sheets, job sheets and a unit test. Special instructions on audiovisuals, supplies, etc. are included in the Notes to the Instructor section near the beginning of each unit.



Competency profile

On the Missouri competency profile, tasks are divided into general subject areas, or duty bands, which are identified by a capital letter. Under each duty band are related tasks (competencies), which are identified by an Arabic numeral. To evaluate the student on performance of the competencies, a 3-2-1-N grading system is used, where:

3 = Mastery - can work independently with no supervision
2 = Requires supervision - can perform job completely with limited supervision
1 = Not mastered - requires instruction and close supervision
N = No exposure - no experience or knowledge in this area

Cross-reference table (color-coded white)

Once the numbering system is understood, this table quickly reveals how the instructional components of the module relate to Missouri competencies. On the competency profile, tasks are divided into general subject areas, or duty bands, which are identified by a capital letter. Under each duty band are related tasks (competencies), which are identified by an Arabic numeral.

On the cross-reference table, unit numbers are represented by Roman numerals (I, II, III, etc.). Lessons within a unit are shown with Arabic numerals. Therefore, the first objective in Lesson 1 is numbered 1.1, the second is 1.2, and so on. Other components of the module (transparencies, handouts, assignment sheets and job sheets) also use this numbering system. By looking at the cross-reference table, the instructor can quickly determine what test questions or job sheets a student needs to receive an evaluation on a particular competency.

Objectives (color-coded white)

Each unit is based on performance objectives which state the measurable unit and specific behavioral or performance objectives that students are expected to achieve. Since the objectives of the unit provide direction for the teaching-learning process, it is important for the teacher and students to have a common understanding of the objectives' intent. Teachers should feel free to add/adapt objectives which will fit the material to student and community needs. Supporting material will, of course, need to be added for any new objectives.

Table of contents, references, notes to the instructor (color-coded pink)

These pages have been coded pink for instructor use only. The reference section lists materials used as sources in developing the material. Special instructions on audiovisuals, supplies, etc. are included in the Notes to the Instructor section.

Information sheets (green)

Presented in outline form for clarity, these pages provide content essential for meeting the cognitive (knowledge) objectives in the unit. Students should study the information sheets before class discussion or completion of assignment sheets. **CAUTION** statements indicate possible equipment damage or bodily injury. Handouts and transparency masters have been keyed in the information sheets for instructional use.

Transparency masters (white)

Transparencies provide information by visually reinforcing or clarifying ideas presented in the information sheets. They are effective when identification is necessary and direct the class's attention to the topic of discussion. Transparencies should be left on the screen only when topics shown are under discussion, however.

Handouts (white)

Whenever more detailed information than can be presented in a transparency is needed, a handout is used. Handouts give the students additional information that can be kept with their class notes or student references.

Assignment sheets (tan)

Assignment sheets furnish paper-and-pencil practice to develop the knowledge necessary as a prerequisite to skill development. They can be given to students for class completion or used as homework assignments. Answer sheets (color-coded pink) can be used by the student or instructor to check progress.

Job sheets (blue)

These evaluation instruments are provided for two purposes: to outline steps of procedure and to check student performance mastery. Job sheets begin with a list of tools and materials needed for the activity. Job sheets furnish potential employers with a picture of skills being taught and performance which might be reasonably expected from a vocational student. The spaces to the right of the page on a job sheet

assist the instructor in evaluating a student on a particular activity. This 3-2-1-N grading system is the same as the one used on the competency profile.

Unit test (yellow)

Competency-based tests are designed to help eliminate subjective testing and to improve student evaluation and accountability. Specific competencies and test questions are linked on the answer key. These unit tests have been written to be used with computerized VAMS (Vocational Administrative Management System), utilizing Scantron sheets for computer-recording of test answers.

The unit test may be eliminated if the competency was thoroughly evaluated by job sheets. However, an emphasis should be placed on cognitive as well as performance skills. If the objective or competency will be evaluated by a job sheet, it is often necessary to determine by a written test whether the student understands enough of the material to perform the job sheet.

SUGGESTED ACTIVITIES

The following list of suggested activities may be helpful, especially to the beginning instructor.

1. Provide students with objective sheet and information sheets.
2. Discuss unit and specific objectives.
3. Discuss information sheets, assignment sheets and/or job sheets, lesson-by-lesson.
4. Have students do assignment sheet(s) to satisfactory levels.
5. Give students unit test.
6. After successful completion of the test, have students do job sheet(s).

Students should perform the following activities.

1. Read objective sheet.
2. Study information sheets.
3. Do assignment sheet(s).
4. Take unit test.
5. Do job sheets.

PACKAGING

This Machine Shop guide has been packaged with the entire class in mind. For the teacher, a complete instructor's guide contains all eight modules. In the student reference, selected portions have been reproduced for student use (objectives page, information sheets, handouts). Student work sheets (assignment sheets, job sheets, unit tests) have been packaged together for student distribution as the instructor deems necessary.

In the student reference, page numbers do not run consecutively because some pages have been removed that appear only in the instructor's guide.

MODULE 3: BENCH WORK AND MATERIAL SCIENCE

CROSS-REFERENCE TABLE OF INSTRUCTIONAL MATERIALS

Competency	Instructional Objective	Transparency Master	Handout	Assignment Sheet	Job Sheet	Test Item	Notes
E1	IX 3.4				IX 3.2	IX 9-23	
E2	I 1.1-2.3	I 1.1,1.2,2.1,2.2			I 2.1	I 1-7	
E3	II 1.1-3.2	II 1.1,2.1	II 1.1,1.2		II 2.1,2.2, 3.1,3.3	II 1-16	
E4	III 1.1,1.2	III 1.1			III 1.1		
E5	III 2.1-2.3			III 2.1	III 2.1,2.2		
E6	IV 1.1-4.1	IV 1.1,1.2,3.1	IV 2.1,2.2, 4.1		IV 4.1	IV 7,13-17,18	Some threading information for E6 and E7 overlaps.
E7	IV 1.1-3.2, 5.1,5.2	IV 1.1,1.2,3.1	IV 2.1,2.2, 5.1		IV 5.1	IV 7,13-17,19,20	
E8	V 1.1,1.2	V 1.1			V 1.1	V 1-11	
E9	VI 1.1-3.4		VI 1.1		VI 3.1	VI 7-14,28	
E10	VI 4.1-5.2	VI 5.1	VI 5.1		VI 4.1,5.1	VI 1-13,15-20,28	
E11	VII 1.1-3.4	VII 3.1			VII 1.1, 2.1, 3.1	VII 1-14	
E12	VI 6.1-6.3	VI 6.1			VI 6.1	VI 21-27	
E13	VIII 1.1,1.2	VIII 1.1,1.2			VIII 1.1,1.2	VIII 1-6,11	
E14	VIII 2.1,2.2				VIII 2.1,2.2	VIII 7-9,11-14	
E15	IX 3.1,3.2		IX 3.1,3.2		IX 3.1		
E16	VIII 2.3				VIII 2.3	VIII 6,10	
E17	IX 1.3,1.4				IX 1.1	IX 1,2,4-6	

Competency	Instructional Objective	Transparency Master	Handout	Assignment Sheet	Job Sheet	Test Item	Notes
E18	IX 1.5				IX 1.2	IX 1	
E19	IX 2.1,2.2	IX 2.1			IX 2.1	IX 1,3,7,8	
E20	IX 3.3				IX 3.2	IX 1,9-23	
F1	X 1.2		X 1.1	X 1.1		X 11-24	
F2	X 1.1					X 10,25, XI 7	X Instr. note--see Lathes Unit VI
F3	XI 1.1,1.2,1.6		XI 1.1-1.2	XI 1.1	XI 1.1	XI 1-6	
F4							X Instr. note--see Lathes Unit VI
F5	XI 1.4,1.5,1.8	XI 1.1-1.4			XI 1.3	XI 11-26	
F6	XI 1.3,1.7				XI 1.2	XI 8-10	

MODULE: BENCH WORK AND MATERIAL SCIENCE

UNIT I: HACKSAWING

UNIT OBJECTIVE

Upon completion of this unit, the student will be able to identify the parts of a hacksaw and understand the principles of blade selection. The student will demonstrate the ability to install a hacksaw blade, hold work for sawing, hold the hacksaw properly and operate it correctly.

SPECIFIC OBJECTIVES

Upon completion of this unit, the student should be able to:

1.1 Identify the parts of a hacksaw.

1.2 Select the correct blade for applications.

2.1 Install a blade in a hacksaw. (competency E2, JS 2.1)

2.2 Demonstrate work-holding principles for rod or bar stock. (competency E2, JS 2.1)

2.3 Cut completely through a 1" diameter mild steel rod, using correct pressure, form and number of cutting strokes per minute. (competency E2, JS 2.1)

MODULE: BENCH WORK AND MATERIAL SCIENCE

UNIT I: HACKSAWING

CONTENTS OF THIS UNIT

A. Objective sheet

B. References

C. Notes to the instructor

D. Lesson plans

1. Lesson 1: INTRODUCTION

   a. Information outline

   b. Transparency masters

      TM 1.1: Hacksaw blade tooth set
      TM 1.2: Pitches of hacksaw blades

2. Lesson 2: HACKSAWING TECHNIQUES AND TIPS

   a. Information outline

   b. Transparency master

      TM 2.1: Work-holding principles
      TM 2.1: Work-holding principles (cont.)

   c. Job sheet

      JS 2.1: Install a blade and cut material with a hacksaw

E. Unit test

F. Answers to unit test

REFERENCES

A. Books

1. Repp, Victor E., and Willard J. McCarthy. Machine Tool Technology. 5th ed. Bloomington, IL: McKnight Publishing Co., 1984.

NOTES TO THE INSTRUCTOR

A. Suggested approaches to teaching this unit

1. The information portions of this unit can be taught either in a classroom or in the shop. It would be helpful to have several hacksaws available for students to manipulate during instruction. Also, a selection of blades of varying pitch may be helpful in conveying blade selection content. Be sure to advise students that the blades are sharp.

2. In Lesson 2 it is recommended that the instructor use a hacksaw throughout the course of the presentation to demonstrate the proper methods of blade installation and hacksaw holding techniques. A selection of materials of varying thickness could be used to demonstrate work-holding problems encountered in using a hacksaw.

3. Workpiece material used with JS 2.1 can be substituted according to the instructor's discretion.

MODULE: BENCH WORK AND MATERIAL SCIENCE

UNIT I: HACKSAWING

LESSON 1: INTRODUCTION

NOTE: It is important for a machinist to hacksaw well because the hacksaw is a basic tool of the machinist. It is used to cut small pieces of metal held in a vise and to cut material in place on machines or equipment.

I. Parts of a hacksaw

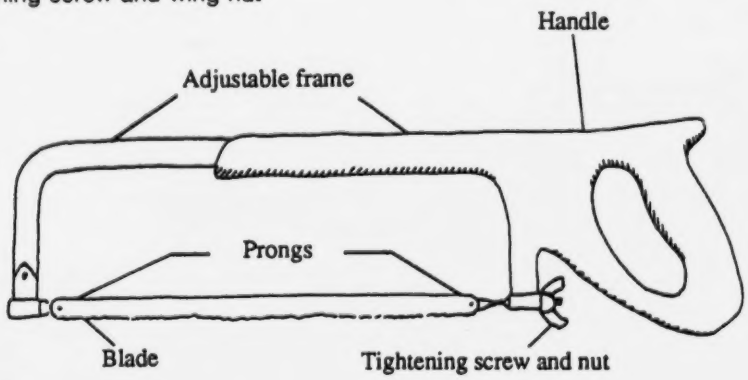
A. Frame--usually adjustable to accommodate varying blade lengths of 8, 10 or 12 inches

B. Handle

C. Prongs

D. Tightening screw and wing nut

E. Blade



II. Specifications of hacksaw blades **(TM 1.1, 1.2)**

NOTE: Hacksaw blades are specified by size, material, blade pitch and tooth set.

A. Size--available in lengths of 8, 10 or 12 inches (200, 250, 300 mm). The most common length is 12" (300 mm).

B. Material--most common materials are carbon or plain steel and high-speed steel. **Carbon steel** blades are inexpensive but do not have long life. **High-speed steel** blades have high alloy content and are more expensive than carbon steel blades. However, they will last much longer if treated with care.

C. Blade **pitch**--determined by the number of teeth per inch (tpi) on the blade. (In the metric system, the number represents the measured distance from one tooth to the next.) The pitch of the blade should correspond to the geometry of material being cut.

1. Blades with 14 tpi (1.8 mm) are most used for cutting soft, ductile materials such as copper, aluminum and soft steel.

2. A pitch of 18 teeth per inch (1.4 mm) is suitable for most materials over 1/4" thick (6 mm).

3. A pitch of 24 tpi (1 mm) is suitable for materials 1/16-1/4" thick (1.6-6 mm), especially for light angle and channel iron, steel pipe and conduit.

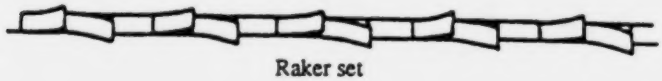
4. Use 32 tpi (.08 mm) for thin sheet materials that are less than 1/16" (1.6 mm) thick.

D. **Tooth set**--refers to the way the teeth of the blade are bent from side to side. This bending makes the cutting portion of the blade wider than the back of the blade and creates a kerf through in which the blade can pass through the workpiece without binding. There are three types of tooth set: raker, straight and wavy.

1. **Raker set**--alternating pattern in which one tooth is bent to the right, one is straight, the next is bent to the left and so on. A raker set is used on blades having 14-18 tpi.

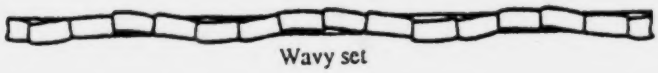
2. **Straight set**--alternating pattern in which one tooth is bent to the right, the next to the left and so on. A straight set is used on blades of 14-18 tpi.

3. **Wavy set**--has several teeth bent to the left alternating with several teeth bent to the right. It is used on blades with pitches of 24, 32 or more.



Raker set

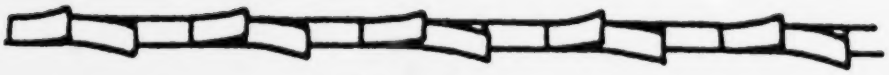
Straight set



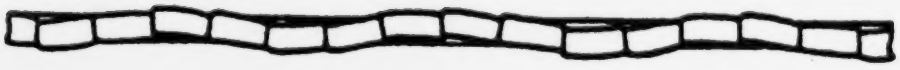
Wavy set

HACKSAW BLADE TOOTH SET

Straight set



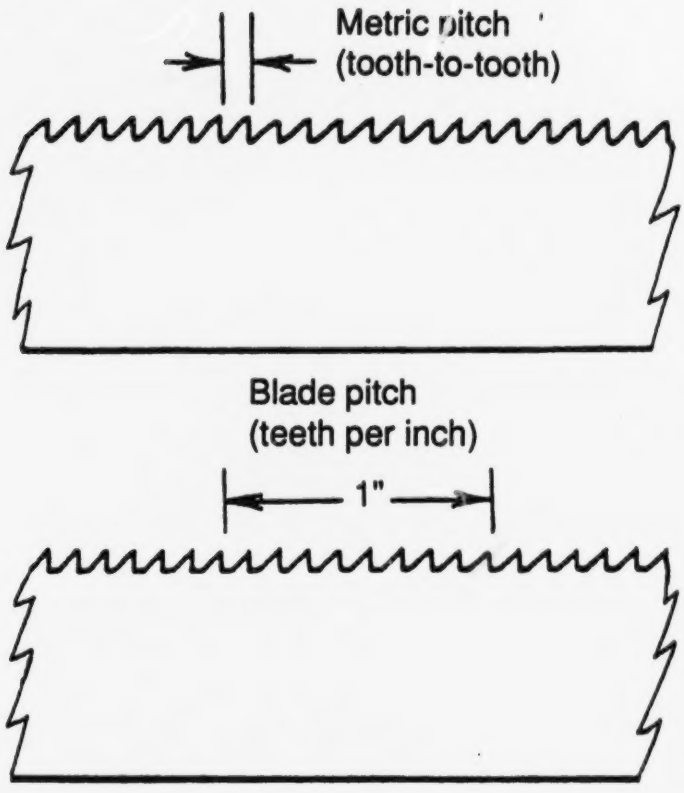
Raker set



Wavy set

Credit: Metalwork: Technology and Practice (from the 1989 or earlier editions of this book). Reproduced with permission of the publisher, Glencoe Publishing Company, Mission Hills, Calif. All rights reserved.

PITCHES OF HACKSAW BLADES



MODULE: BENCH WORK AND MATERIAL SCIENCE

UNIT I: HACKSAWING

LESSON 2: HACKSAWING TECHNIQUES AND TIPS

I. Installing a hacksaw blade

CAUTION: Handle hacksaws carefully as blades are very sharp.

A. The hacksaw frame must be adjusted to the correct length for the blade being installed.

B. Blade should have teeth pointing forward or away from the handle.

C. Hooks on the frame and the tightening screw are placed in holes in either end of the blade; the wing nut is then hand-tightened.

II. Work-holding techniques **(TM 2.1, 2.2)**

CAUTION: A hacksaw should never be used on work being held in someone's hand. The saw could slip and cause injury. Safety glasses must be worn when using a hacksaw.

A. Work to be sawed should be held in a bench vise. It must be clamped tightly enough to prevent it from moving while being sawed, but not so tight as to damage the work.

B. Soft jaw caps of plastic, copper or brass should be used to cover the jaws of the bench vise to prevent damage to a workpiece made of soft material.

C. Care must be taken in cutting thin materials. As a general rule, the pitch of the blade should be such that no fewer than two teeth should contact the edge being cut. Extremely thin material should be "sandwiched" between two other pieces (e.g. blocks of wood) and then held in a vise to prevent it from bending.

III. Using a hacksaw

NOTE: Proper technique when using a hacksaw is essential for efficiency and safety.

A. When holding the hacksaw, the handle should be grasped with the dominant hand while the other is used to grip the end of the frame. A proper stance is also important. Stand close to the work with feet spread slightly apart to provide good balance.

B. Cutting stroke consists of a pulling stroke and return stroke. Since the teeth of the blade are pointed away from the handle, the hacksaw will only cut on the pulling stroke.

1. Saw lightly when starting a cut until the cut is deep enough to prevent the blade from jumping out. Apply pressure on the pulling stroke and lift up slightly on the return.

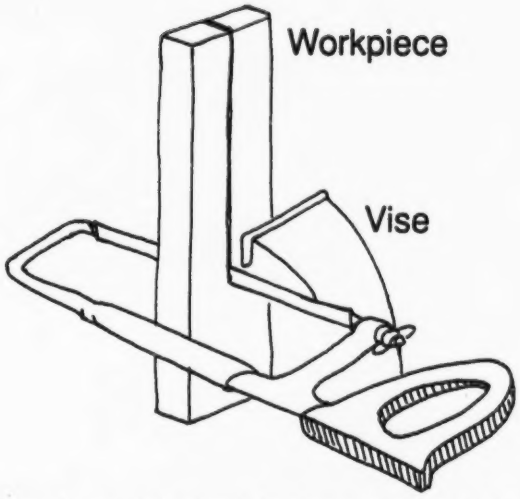
2. A good speed for cutting is about 40 strokes per minute. Sawing faster does not improve cutting efficiency and is unsafe.

3. After the first few strokes the blade of the saw will begin to warm and expand. Tighten the blade periodically while cutting to keep it taught.

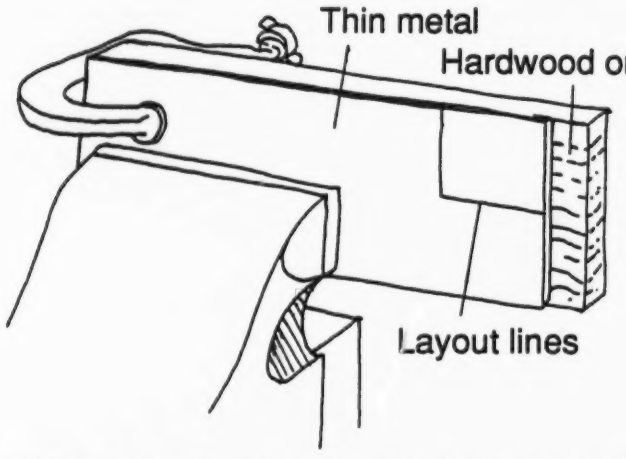
4. The tightening screw permits the saw to turn at 90° to the blade. This is useful when a nut must be where there is not enough clearance for the frame.

5. Replace blade when the sides of the cutting portion have worn smooth and are no longer producing a kerf with clearance for the blade. A blade with missing teeth or cracks should also be replaced.

WORK-HOLDING PRINCIPLES

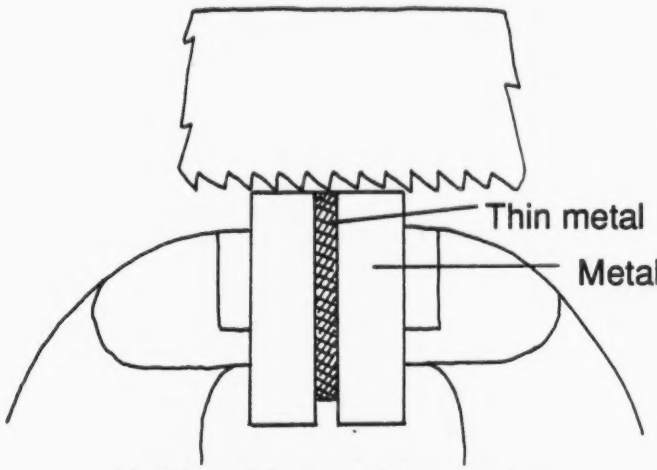


Sawing with the blade set at a right angle to the frame

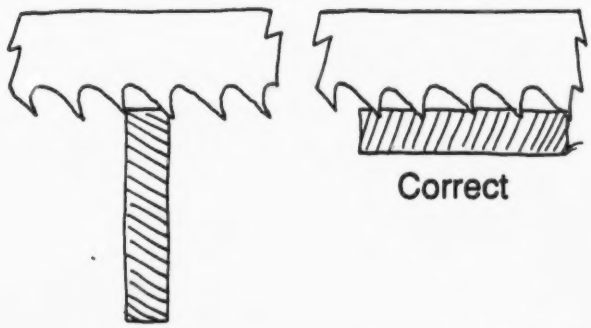


Holding thin metal so layout lines are visible

WORK-HOLDING PRINCIPLES (cont.)



Holding thin metal for sawing



Wrong

At least two teeth should contact the workpiece to prevent the stripping of teeth.

INSTALL A BLADE AND CUT MATERIAL WITH A HACKSAW

Equipment:

Hand hacksaw
12" (300 mm) high speed steel hacksaw blade (18 tpi/1.4 mm pitch)
Bench vise with soft jaws
Length of 1" (25 mm) diameter mild steel rod, hot or cold rolled
Safety glasses
Bench rule
Scriber

Procedure:		Evaluation 3	2	1	N
1.	Install blade in hacksaw frame with teeth facing away from the handle. Hand-tighten wing nut.	—	—	—	—
2.	Mark workpiece with scriber 1" (25 mm) from one end.	—	—	—	—
3.	Secure workpiece in vise with scribe mark extending just outside the vise jaw. Remember, placing the line of cut close to the vise jaw provides additional stability and accuracy.	—	—	—	—
4.	Grip saw by placing the handle in your dominant hand and grasping the end of the frame with the other hand.	—	—	—	—
5.	Start cut with light, short stokes until the groove is deep enough to prevent the blade from jumping out. Retighten the blade as needed.	—	—	—	—
6.	Increase to full strokes using at least three-quarters of the blade's length. Apply pressure on the pulling stroke and lift up slightly on the return. Cut with an even rhythm at near 40 pulling strokes per minute.	—	—	—	—
7.	Continue cutting through the workpiece. Cut produced should be 90° (±10°) to the center line of the workpiece.	—	—	—	—
8.	As directed by instructor, prepare for next job sheet or clean up area and return tools and materials.	—	—	—	—
Average of above evaluations*		—	—	—	—

*This average is the student's final evaluation for competency E2: Cut materials with hand hacksaw.

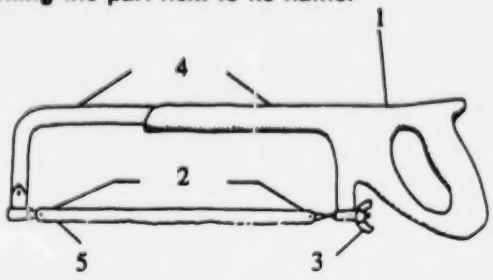
MODULE: BENCH WORK AND MATERIAL SCIENCE

UNIT I: HACKSAWING

UNIT TEST

Match parts of the hacksaw by placing the letter representing the part next to its name.

____ 1.	a.	Frame
____ 2.	b.	Handle
____ 3.	c.	Blade
____ 4.	d.	Prongs
____ 5.	e.	Tightening screw and wing nut



Select the best answer for the items below.

____ 6. Which statement is false?

a. Pitch refers to the angle at which the blade is installed in the frame.
b. A raker set will usually be found on blades with 14-18 teeth per inch.
c. A hacksaw blade must be installed with the teeth pointing away from the handle.
d. The hacksaw cuts only on the pulling stroke, so it is not necessary to apply pressure on the return stroke.
e. None of the above

____ 7. Which statement is false?

a. A good cutting speed for hand hacksawing is 40 strokes per minute.
b. It is not necessary to wear safety glasses when hacksawing.
c. The wing nut should be tightened after several strokes of the hacksaw as the blade will warm-up and become loose.
d. Kerf is the cut made by the saw blade.
e. None of the above

ANSWERS TO UNIT TEST (E2)

1. b
2. d
3. e
4. a
5. c
6. a
7. b

MODULE: BENCH WORK AND MATERIAL SCIENCE
UNIT II: FILING/DEBURRING

UNIT OBJECTIVE

Upon completion of this unit, the student will be able to manipulate a file to smooth surfaces and deburr corners. The student will also demonstrate cleaning a file and will be able to use a universal deburring tool for deburring corners and drilled holes. This knowledge will be evidenced by achieving the specified score on job sheets and the unit test.

SPECIFIC OBJECTIVES

Upon completion of the lessons in this unit, the student will be able to:

1.1 Identify the importance of filing in machine shop work.

1.2 Identify the parts or features of a file.

1.3 Interpret specifications for files.

2.1 Match files to various types of applications.

2.2 Mount a handle on a file tang.

2.3 Smooth and square the face of a workpiece using draw filing technique. (competency E3, JS 2.1)

2.4 Deburr the 90° corner of a mild steel workpiece using a file. (competency E3, JS 2.2)

2.5 Clean a file properly using a file card.

3.1 Deburr a corner using a deburring tool. (competency E3, JS 3.1)

3.2 Deburr a drilled hole with a deburring tool. (competency E3, JS 3.2)

MODULE: BENCH WORK AND MATERIAL SCIENCE

UNIT II: FILING/DEBURRING

CONTENTS OF THIS UNIT

A. Objective sheet

B. References

C. Notes to the Instructor

D. Lesson plans

1. Lesson 1: IMPORTANCE OF FILING/FILE SPECIFICATIONS

   a. Information outline

   b. Transparency master

      TM 1.1: Parts of a file

   c. Handouts

      HO 1.1: File shapes
      HO 1.2: File cuts and coarseness

2. Lesson 2: FILE APPLICATIONS

   a. Information outline

   b. Transparency master

      TM 2.1: Holding a file for draw filing

   c. Job sheets

      JS 2.1: Smooth and square workpiece using draw filing technique
      JS 2.2: Deburr a corner using cross-filing technique

3. Lesson 3: USING A DEBURRING TOOL

   a. Information outline

   b. Job sheets

      JS 3.1: Deburr a corner using a deburring tool
      JS 3.2: Deburr a drilled hole with a deburring tool

E. Unit test

F. Answers to unit test

REFERENCES

A. Book

1. Repp, Victor E., and Willard J. McCarthy. Machine Tool Technology. 5th ed. Bloomington, IL: McKnight Publishing Co., 1984.

B. Curriculum guides

1. Grimes, L. Machinist. Austin: Center for Occupational Curriculum Development, University of Texas at Austin, 1982.

2. Yettaw, Jerome. Vocational Machine Shop. University of Missouri-Columbia: Instructional Materials Laboratory, 1977.

MODULE: BENCH WORK AND MATERIAL SCIENCE

UNIT II: FILING/DEBURRING

LESSON 1: IMPORTANCE OF FILING/FILE SPECIFICATIONS

I. Uses of filing

A. Final fitting

B. Creation of part geometry not achievable by machine

C. Deburring, which improves appearance, accuracy and safety

D. Permits "final touch" to work

II. General description and parts of a file **(TM 1.1)**

A. File--hardened piece of steel into which slanting rows of teeth have been formed. It is used to cut, smooth and shape metal parts. A file can cut most materials except hardened steel.

CAUTION: In addition to being extremely hard, a file is also very brittle and fragile. For this reason it should never be used for striking another object or as a prying device. This could cause the file to shatter and release sharp particles into the air, causing eye injury.

B. Parts of a file

1. Point--endmost part of the file which is held away from the operator

2. Face--wide, flat portion of the file surface which is covered with the cutting teeth

3. Heel--intersection of tang and face (body) of file

4. Tang--pointed portion of the file which receives the handle

CAUTION: For safety, all files should have a handle over the tang. The tang is sharp and can easily puncture the palm of a machinist's hand.

5. Edge--at 90° to the face; can have teeth or be smooth. A smooth edge is referred to as a safe edge as it will not cut.

III. Classifications of files **(HO 1.1, 1.2)**

NOTE: File types and applications are numerous. Selection of the proper file for a job requires knowledge of the following.

A. The **size** of a file is determined by its linear distance from the heel to the point. As length increases, width and thickness also increase.

B. Files come in various **shapes** according to the contour of a file's cross-section. **(HO 1.1)**

C. **Cut** refers to the tooth pattern on the face of the file.

1. Single

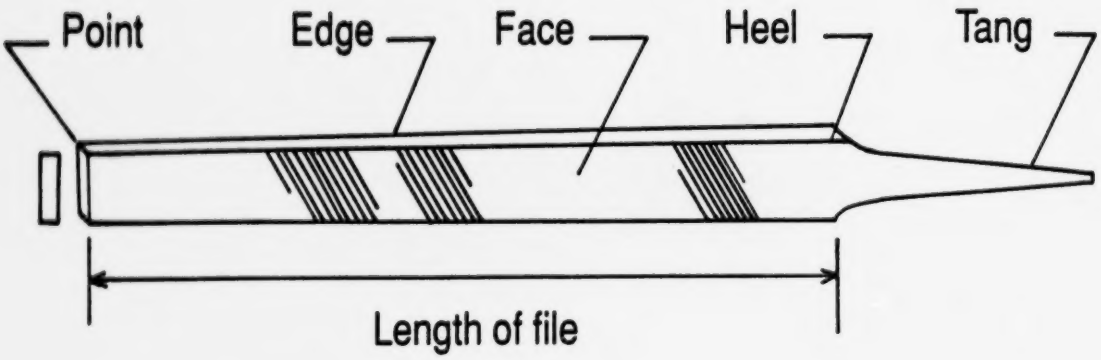
2. Double

3. Rasp

4. Curved

D. **Coarseness** refers to the spacing between the rows of teeth on single-cut and double-cut files. Files range in coarseness from rough to dead smooth. **(HO 1.2)**

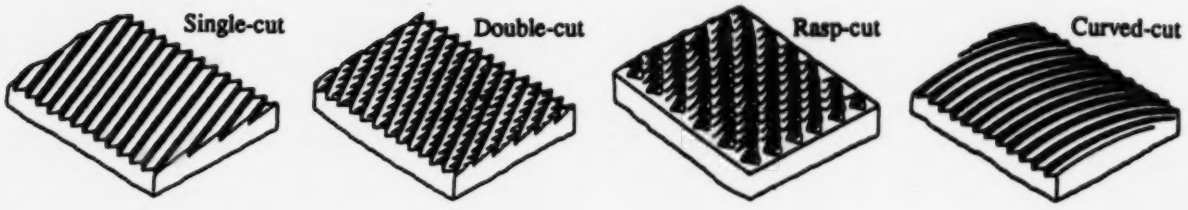
PARTS OF A FILE

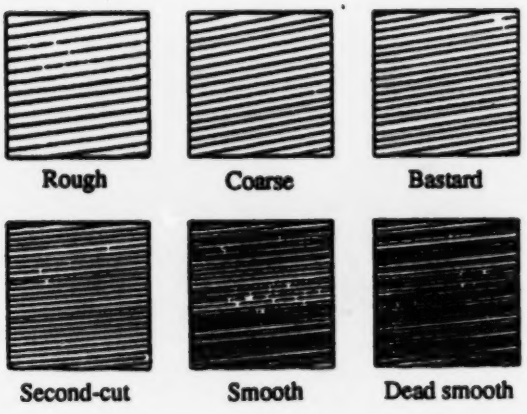


FILE SHAPES

Type, description and symbol	Cut single (S) double (D)	Uses
Flat (tapered width and thickness)	D	For general work; one of the most commonly used files because of rapid metal removal
Half-round (about one-third of a circle; tapered)	D	Curved surface filing
Hand (one safe edge; equal in width and tapered in thickness)	D	Flat surface finishing; useful where the flat file cannot be used because of the safe edge
Mill (tapered or blunt)	S	Draw filing, finishing and lathe work; brass and bronze finishing work; sharpening mill or circular saws
Pillar (one safe edge; narrower and thicker than a hand file; equal in width and tapered in thickness)	D	Narrow work such as keyways, slots and grooves
Round or rat-tail (slightly tapered)	S/D	Filing bowed surfaces, enlarging round holes, forming fillets (spacer piece that fills an angle made by two sharp-angled connecting surfaces)
Square (tapered or blunt)	D	Square or rectangular corners
Three-square (tapered, triangular in the cross section)	D	Filing corners and angles less than 90

FILE CUTS AND COARSENESS





Credit: Metalwork Technology and Practice (from the 1989 or earlier editions of this book). Reproduced with permission of the publisher, Glencoe Publishing Company, Mission Hills, Calif. All rights reserved.

MODULE: BENCH WORK AND MATERIAL SCIENCE

UNIT II: FILING/DEBURRING

LESSON 2: FILE APPLICATIONS

I. Holding the file and workpieces

A. Workpiece rules

1. To be safe, never hold a workpiece that is being filed in your hand. Always use a work-holding device such as a bench vise.

2. Use soft jaws to protect polished surfaces.

B. Holding the file

1. Always use a handle. The sharp tang can cause injury.

2. Never seat a file handle by tapping the file with a hammer. Place the tang in the handle and tap the handle on a bench until it is firmly seated.

3. Select the appropriate file for a job considering factors in Lesson 1.

II. Filing techniques **(TM 2.1)**

CAUTION: Always wear safety glasses when filing.

A. Draw filing--produces a smooth, flat surface

1. Grasp file at point and heel and hold at 90° to longest dimension being filed.

2. Push file back and forth across workpiece, applying pressure only on the pulling stroke.

B. Cross-filing (deburring)--filing technique used for deburring a workpiece

CAUTION: Burrs are sharp edges produced on the corner of a workpiece by machining operations. Burrs must be removed as they can cause injury, reduce accuracy and detract from the appearance of finished parts.

1. Hold file naturally at 45° angle to the workpiece edge to be filed.

2. Use "three-point" filing technique. File first at 15° to the top of the workpiece, then at 15° to the side of the workpiece. Finally, file at 45° to the top of the workpiece. (The minimum number of strokes is three.)

CAUTION: Do not test the edge with fingers to see if the burr has been removed. Inspect the corner of the workpiece visually.

III. Cleaning and storing files

A. File card--used to clean a file. Rub card across file width to remove pins (chips) which clog the teeth and reduce cutting effectiveness.

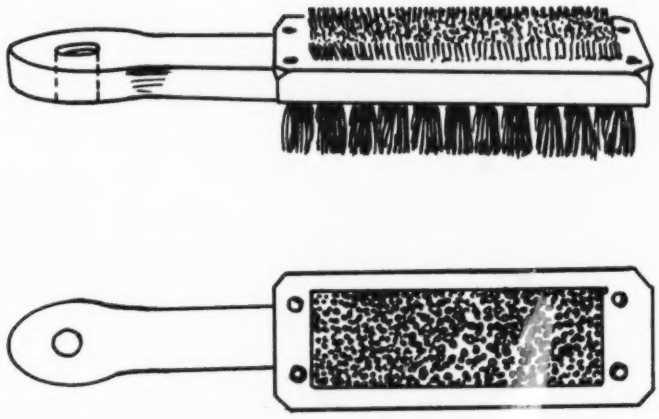
B. Storing and caring for files

1. Keep separated--they can damage each other if left to roll about in drawer.

2. Keep dry and free of oil and solvents.

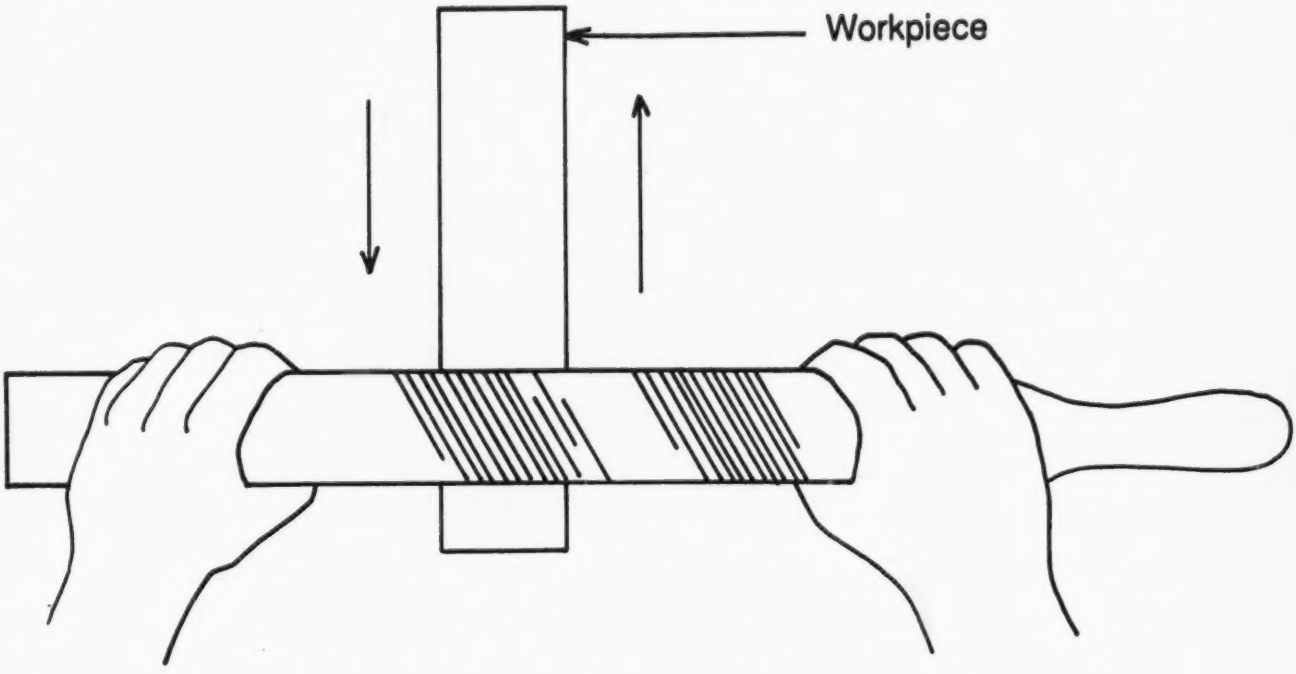
3. If a file does become oily, chalk the teeth. Chalk rubbed into the teeth will prevent pins from being wedged into the teeth when filing soft materials.

4. File cards, which are similar to wire brushes, are used to clean files.



File card (side and top views)

HOLDING A FILE FOR DRAW FILING



Apply pressure only when pulling <u>toward</u> you.

SMOOTH AND SQUARE WORKPIECE USING DRAW FILING TECHNIQUE

Equipment:

10 or 12" mill or smooth single-cut file
File handle
Bench vise with soft jaws
6" long block of 1 x 1 cold rolled mild steel bar
Combination square
Safety glasses
Layout die
File card

NOTE: Draw filing is the process of operating a file such that it is held 90° to the workpiece being filed to create a smooth, square surface.

CAUTION: Safety glasses must be worn when filing.

Procedure:		Evaluation 3	2	1	N
1.	Seat tang of file in handle by tapping handle firmly on bench top.	—	—	—	—
2.	Secure the workpiece in the vise with the length of the workpiece parallel to the vise jaws. Scribe line using scriber and combination square at 90° to length of workpiece.	—	—	—	—
3.	Grip the file firmly with one hand at the heel and the other at the point.	—	—	—	—
4.	Pull the file across the workpiece with even pressure (toward the body).	—	—	—	—
5.	Check the squareness of the workpiece with the combination square periodically to ensure that a square, true surface is being maintained. The finished surface should be smooth, square and free of score marks.	—	—	—	—
6.	Clean file with file card.	—	—	—	-
7.	As directed by instructor, prepare for next job sheet or clean up area and return tools and materials.	—	—	—	—
Average of above evaluations*		—	—	—	—

*This average is one-quarter of the student's final evaluation for competency E3: Bench file/deburr workpiece.

DEBURR A CORNER USING CROSS-FILING TECHNIQUE

Equipment:

10" or 12" mill or smooth single-cut file
File handle
Bench vise with soft jaws
6" long block of 1 x 1 cold rolled mild steel bar
Safety glasses
Layout die
File card

CAUTION: Safety glasses must be worn when filing.

Procedure:		Evaluation 3	2	1	N
1.	Seat tang of file in handle by tapping handle firmly on bench top.	—	—	—	—
2.	Secure workpiece in vise with length of workpiece parallel to vise jaws.	—	—	—	—
3.	Hold file firmly with handle in the dominant hand and the other hand securing the point with the thumb and index finger.	—	—	—	—
4.	Position file at a 45° to the length of the workpiece. Tilt the file to approximately 15° of the top surface of the workpiece. Using a pulling stroke, file the corner of the workpiece.	—	—	—	—
5.	Repeat this procedure with the file tilted at 15° to the side of the workpiece.	—	—	—	—
6.	Repeat once more with the file at 45° to the top of the workpiece.	—	—	—	—
7.	Inspect corners. The edges should be smooth with no burrs or sharp corners present.	—	—	—	—
8.	Repeat on the remaining three lengthwise edges.	—	—	—	—
9.	As directed by instructor, prepare for next job sheet or clean up area and return tools and materials.	—	—	—	—
Average of above evaluations*		—	—	—	—

*This average is one-quarter of the student's final evaluation for competency E3: Bench file/deburr workpiece.

MODULE: BENCH WORK AND MATERIAL SCIENCE

UNIT II: FILING/DEBURRING

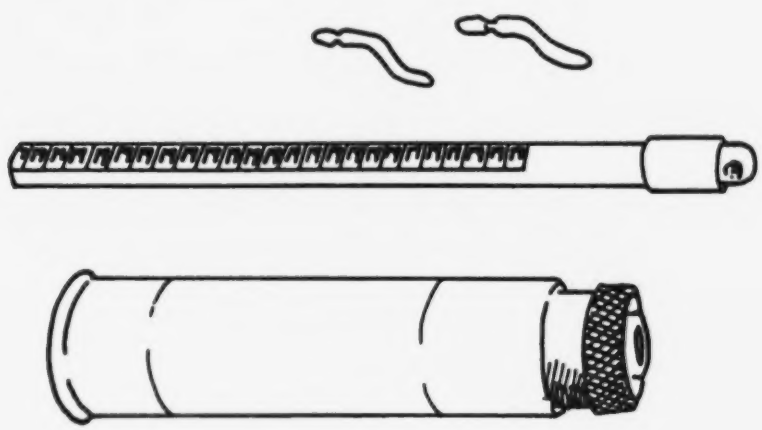
LESSON 3: USING A DEBURRING TOOL

I. Deburring tool--alternative to file deburring

A. Faster

B. Safer

C. Greater flexibility

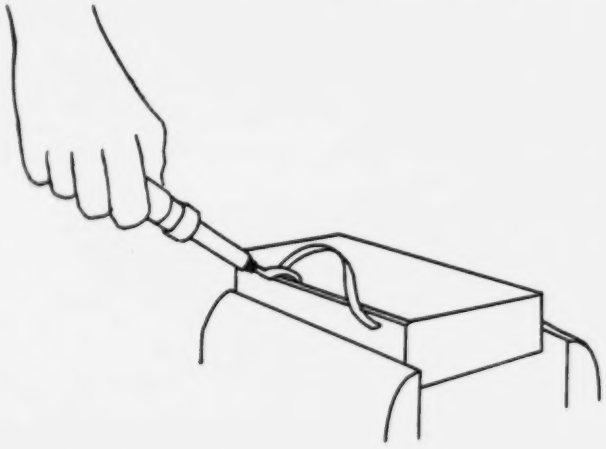


DEBURR A CORNER USING A DEBURRING TOOL

Equipment:

Standard plastic handled universal deburring tool
Basic high-speed steel blade
Bench vise with soft jaws
Safety glasses
6" long block of 1 x 1 cold rolled mild steel bar
Layout die
File card

Procedure:	Evaluation 3	2	1	N
1. Secure the workpiece in the vise with length parallel to the vise jaws.	—	—	—	—
2. Hold deburring tool in dominant hand. Tilt handle to engage blade as shown below.	—	—	—	—



3. Pull blade along corner of workpiece. A single, continuous shaving should be produced. The corner should now be smooth and free of sharp edges or burrs.	—	—	—	—
4. Turn in vise as necessary and repeat until all long edges are smooth.	—	—	—	—
5. As directed by instructor, prepare for next job sheet or clean up area and return tools and materials.	—	—	—	—
Average of above evaluations*	—	—	—	—

*This average is one-quarter of the student's final evaluation for competency E3: Bench file/deburr workpiece.

DEBURR A DRILLED HOLE USING A DEBURRING TOOL

Equipment:

Standard plastic handled universal deburring tool
Basic high-speed steel blade
Bench vise with soft jaws
Safety glasses
1/2" aluminum or mild steel plate (4" x 6" with four 3/4" holes drilled through)
Layout die
File card

Procedure:	Evaluation 3	2	1	N
1. Secure the workpiece in the vise with length parallel to the vise jaws.	—	—	—	—
2. Hold deburring tool in dominant hand. Tilt handle to engage blade as shown below.	—	—	—	—
3. Pull blade around outside edge of the hole. A single, continuous shaving should be produced. The corner should now be smooth and free of any burrs produced by drilling.	—	—	—	—
4. Repeat until both ends of all holes have been properly deburred.	—	—	—	—
5. Clean up area and return tools and materials.	—	—	—	—
Average of above evaluations*	—	—	—	—

*This average completes the student's evaluation for competency E3: Bench file/deburr workpiece.

MODULE: BENCH WORK AND MATERIAL SCIENCE

UNIT II: FILING/DEBURRING

UNIT TEST

Match the file part names listed below with the appropriate letter on the illustration.

___ 1. Length

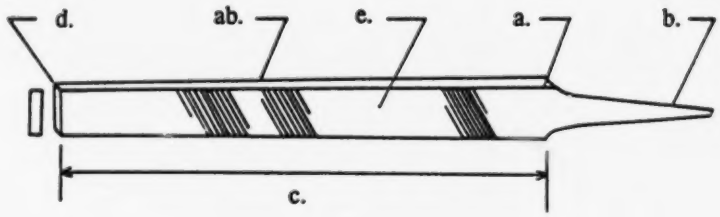
___ 2. Point

___ 3. Heel

___ 4. Tang

___ 5. Edge

___ 6. Face



Match the file shape names listed below with the letter representing the correct file cross-section shown.

___ 7. Flat

___ 8. Rat-tail

___ 9. Half-round

___ 10. Three-square

a.

b.

c.

d.

Select the option which answers the question or completes the statement.

___ 11. Which is an incorrect file use?

a. Final fitting
b. Improve appearance
c. Improve accuracy
d. Improve safety
e. Remove a large amount of material quickly

___ 12. Which file cut is best suited for fast metal removal on soft material?

a. Single
b. Double
c. Rasp
d. Curved
e. None of the above

____ 13. Identify the filing technique which produces a smooth, flat surface.

a. Cross-filing
b. Draw filing
c. Corner filing
d. Deburring
e. None of the above

____ 14. What is the minimum number of strokes required to properly deburr a corner with a file?

a. 1
b. 2
c. 3
d. 4
e. 5

____ 15. Which is an advantage of using a deburring tool to deburr a workpiece?

a. It is faster.
b. It is safer.
c. It offers more flexibility.
d. It requires no cleaning.
e. All of the above

ANSWERS TO UNIT TEST (E3)

1. c
2. d
3. a
4. b
5. ab
6. e
7. b
8. c
9. a
10. d
11. e
12. d
13. b
14. c
15. e

MODULE: BENCH WORK AND MATERIAL SCIENCE
UNIT III: LOCATING CENTERS FOR DRILLING

UNIT OBJECTIVE

Upon completion of this unit, the student will be able to identify various methods of locating and transferring hole locations, demonstrate use of prick and center punches, and locate and transfer holes with transfer screws and punches. This knowledge will be evidenced by achieving the specified score on the assignment sheet and job sheets.

SPECIFIC OBJECTIVES

Upon completion of the lessons in this unit, the student should be able to:

1.1 Identify prick and center punches.

1.2 Mark locations with prick and center punches. (competency E4, JS 1.2)

2.1 Identify transfer screws and transfer punches.

2.2 Locate through threaded holes with transfer screws. (competency E5, JS 2.1)

2.3 Locate through holes with transfer punches. (competency E5, JS 2.2)

MODULE: BENCH WORK AND MATERIAL SCIENCE

UNIT III: LOCATING CENTERS FOR DRILLING

CONTENTS OF THIS UNIT

A. Objective sheet

B. References

C. Notes to the instructor

D. Lesson plans

1. Lesson 1: HOLE LAYOUT

   a. Information outline

   b. Transparency master

      TM 1.1: Prick and center punches

   c. Job sheet

      JS 1.1: Mark locations with prick and center punches

2. Lesson 2: HOLE TRANSFER

   a. Information outline

   b. Assignment sheet

      AS 2.1: Transfer screws and punches

   c. Job sheets

      JS 2.1: Transfer threaded hole locations with transfer screws
      JS 2.2: Locate through holes with transfer punches

REFERENCES

A. Books

1. Apprentice Machinist (AFSC 53130). Vol. I. Machine Shop Fundamentals. Gunter Air Force Base, AL: Extension Course Institute, Air University, 1981.

2. Repp, Victor E., and Willard J. McCarthy. Machine Tool Technology. 5th ed. Bloomington, IL: McKnight Publishing Co., 1984.

MODULE: BENCH WORK AND MATERIAL SCIENCE

UNIT III: LOCATING CENTERS FOR DRILLING

LESSON 1: HOLE LAYOUT

I. Punches **(TM 1.1)**

A. Prick punch

1. 30° included angle

2. Fine, sharp point to pick up centerline marks easily

B. Center punch

1. 60-90° included angle

2. Expands the punch mark created by the prick punch; aids in guiding a drill so it will stay on center

II. Safe applications

A. Use punches for semi-precision hole layout.

B. Punches are not suitable for high-precision hole location.

C. Safety glasses are required for use.

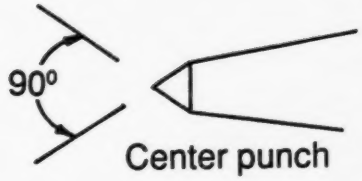
CAUTION: Even a hardened tool can shatter--do not strike against another hardened surface or tool.

D. The head or striking end can mushroom from repeated use. Do not use in this condition. Use pedestal grinder to restore the end.

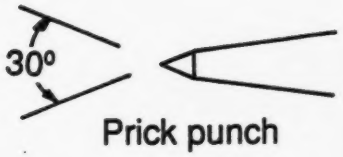
PRICK AND CENTER PUNCHES

Center punch

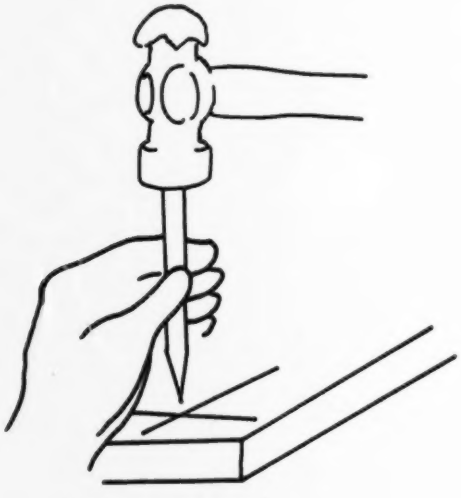
Prick punch



Center punch



Prick punch



Using a punch

MARK LOCATIONS WITH PRICK AND CENTER PUNCHES

Equipment:

Prick punch
Center punch
12 or 16 oz. ball-peen hammer
Layout die
Combination square
Scribe
Safety glasses
Work bench
1/4-1/2" thick aluminum or mild steel plate, 4 x 6"

Procedure:	Evaluation 3	2	1	N
CAUTION: Safety glasses must be worn when using prick and center punches.				
1. Coat one face of workpiece with layout die. Allow to dry.	—	—	—	—
2. Using combination square and scribe, layout centers.	—	—	—	—
3. Place point of prick punch near one intersection. Tilt punch and carefully place point of punch at intersection. Adjust prick punch to a vertical position and hold steady. Strike punch lightly with ball-peen hammer.	—	—	—	—
4. Inspect prick punch mark for accuracy.	—	—	—	—
5. Place center punch in a vertical position in prick punch mark. Strike center punch soundly with hammer.	—	—	—	—
6. As directed by instructor, prepare for next job sheet or clean up area and return tools and materials.	—	—	—	—
Average of above evaluations*	—	—	—	—

*This average is the student's final evaluation for competency E4: Mark locations with prick and center punches.

MODULE: BENCH WORK AND MATERIAL SCIENCE

UNIT III: LOCATING CENTERS FOR DRILLING

LESSON 2: HOLE TRANSFER

I. Transfer screws

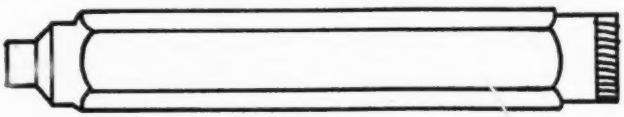
A. Use transfer screws to transfer the location of threaded holes.

B. The thread designation of the transfer screw must match that of the threaded hole.

1. Metric

2. English

C. A transfer screw set contains transfer points and a holder/installation wrench.



II. Transfer punches

A. Transfer punches are used to transfer the location of through holes.

B. The transfer punch diameter must match that of the holes being transferred.

1. Metric

2. English

TRANSFER SCREWS AND PUNCHES

Select the option which best answers the question or completes the statement.

___ 1. What included angle is on the tip of a prick punch?

a. 5
b. 30
c. 60
d. 90
e. 120

___ 2. What angle is on the tip of a center punch?

a. 5
b. 15
c. 30
d. 90
e. 120

___ 3. Which of the following statements is false?

a. Mushroomed heads must be redressed.
b. Safety glasses must be worn when using prick and center punches.
c. A prick punch can be used as a cutting tool.
d. A center punch aids in guiding a drill.
e. None of the above

___ 4. Which device is used to transfer the location of threaded holes?

a. Prick punch
b. Center punch
c. Transfer punch
d. Transfer screws
e. None of the above

___ 5. Which device is used to transfer the location of through holes?

a. Prick punch
b. Center punch
c. Transfer punch
d. Transfer screw
e. None of the above

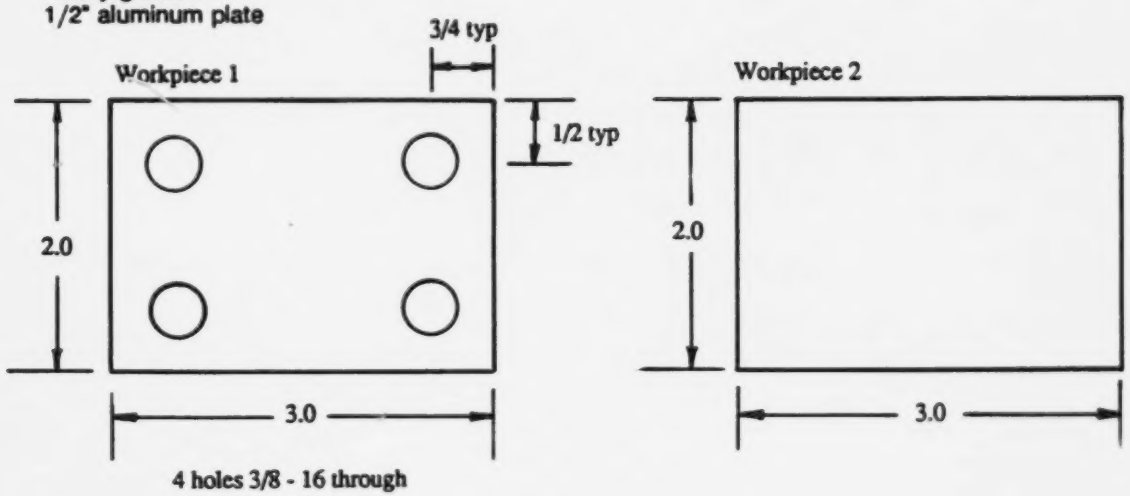
ANSWERS TO AS 2.1

1. b
2. d
3. c
4. d
5. c

TRANSFER THREADED HOLE LOCATIONS WITH TRANSFER SCREWS

Equipment:

Set of 3/8-16 NC transfer screws
Light rubber-faced mallet
Workpiece #1 as per drawing below
Workpiece #2 as per drawing below
Layout die
Safety glasses
1/2" aluminum plate



Procedure:	Evaluation 3	2	1	N
1. Coat one face of workpiece #2 with layout die. Allow to dry.	—	—	—	—
2. Install one transfer screw in each threaded hole in workpiece #1 such that only the point extends above the surface of the work.	—	—	—	—
3. Place workpiece #1 with the transfer points down onto the top of workpiece #2. Strike the top of the assembly once with the rubber mallet. The center locations of the tapped holes will be transferred to workpiece #2.	—	—	—	—
4. As directed by instructor, prepare for next job sheet or clean up area and return tools and materials.	—	—	—	—
Average of above evaluations*	—	—	—	—

*This average is one-half of the student's final evaluation for competency E5: Locate holes with transfer screws and transfer punches.

LOCATE THROUGH HOLES WITH TRANSFER PUNCHES

Equipment:

Set of metric or English transfer punches
10 or 12 oz. ball-peen hammer
Layout die
Safety glasses
Workpiece #1 as per JS 2.1
Workpiece #2 as per JS 2.1
1/2" aluminum plate
C-clamp

NOTE: Use the same workpieces as in JS 2.1, but use the opposite face of workpiece #2.

Procedure:	Evaluation 3	2	1	N
CAUTION: Safety glasses must be worn when using transfer punches.				
1. Coat one face of workpiece #2 with layout die. Allow to dry.	—	—	—	—
2. Place workpiece #1 on top of workpiece #2. Using C-clamps, secure to work bench. Place a 5/16" (8 mm) transfer punch through a hole in workpiece #1 until it contacts the surface of workpiece #2. Tap the head of the punch with the ball-peen hammer.	—	—	—	—
3. Without moving either workpiece, repeat this process on the remaining holes.	—	—	—	—
4. Clean up area and return tools and materials.	—	—	—	—
Average of above evaluations*	—	—	—	—

*This average completes the student's evaluation for competency E5: Locate holes with transfer screws and transfer punches.

MODULE: BENCH WORK AND MATERIAL SCIENCE
UNIT IV: CUTTING THREADS WITH TAP AND DIE

UNIT OBJECTIVE

Upon completion of this unit, the student should be able to identify screw thread terminology and specifications, select taps and dies for given applications and cut threads with both tap and die. This knowledge will be evidenced by achieving a specified score on job sheets and the unit test.

SPECIFIC OBJECTIVES

Upon completion of the lessons in this unit, the student should be able to:

1.1 Identify thread uses.

1.2 Identify methods of thread manufacture.

2.1 Identify parts of a thread.

2.2 Specify and interpret thread designations.

3.1 Measure thread angles.

3.2 Measure screw pitch and diameter.

4.1 Cut external threads using a die and diestock. (competency E6, JS 4.1)

5.1 Identify tap specifications.

5.2 Cut threads using taps and tap wrench. (competency E7, JS 5.1)

MODULE: BENCH WORK AND MATERIAL SCIENCE

UNIT IV: CUTTING THREADS WITH TAP AND DIE

CONTENTS OF THIS UNIT

A. Objective sheet

B. References

C. Notes to the instructor

D. Lesson plans

1. Lesson 1: SCREW THREADS DEFINED

   a. Information outline

   b. Transparency masters

      TM 1.1: Screw thread uses
      TM 1.2: Screw thread manufacture

2. Lesson 2: THREAD NOMENCLATURE AND SPECIFICATIONS

   a. Information outline

   b. Handouts

      HO 2.1: Thread forms
      HO 2.2: Comparison of ISO metric and Unified threads

3. Lesson 3: THREAD MEASUREMENT

   a. Information outline

   b. Transparency master

      TM 3.1: Acme thread measurement gages

4. Lesson 4: CUTTING THREADS WITH A DIE

   a. Information outline

   b. Handout

      HO 4.1: Die parts and diestock

   c. Job sheet

      JS 4.1: Cut external threads with a die

5. Lesson 5: CUTTING INTERNAL THREADS WITH A TAP

   a. Information outline

   b. Handout

      HO 5.1: Tap drill chart

   c. Job sheet

      JS 5.1: Cut internal threads with a tap

E. Unit test

F. Answers to unit test

REFERENCES

A. Books

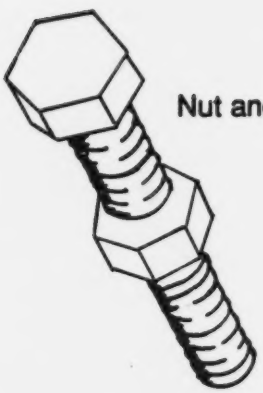
1. Krar, S. F. and J. W. Oswald. Turning Technology. Albany, NY: Delmar, 1971.

2. Repp, Victor E., Willard J. McCarthy and Oswald A. Ludwig. Metalwork Technology and Practice. Bloomington, Ill.: McKnight Publishing Co., 1982.

B. Curriculum guide

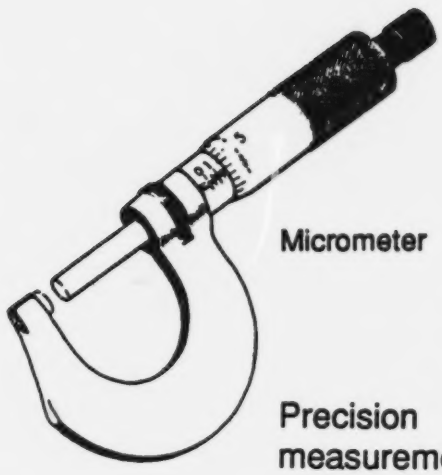
1. Benson, Robert T., and Margaret R. Gregory. V-TECS Guide for Machine Shop. Columbia, SC: South Carolina Department of Education, 1985.

SCREW THREAD USES



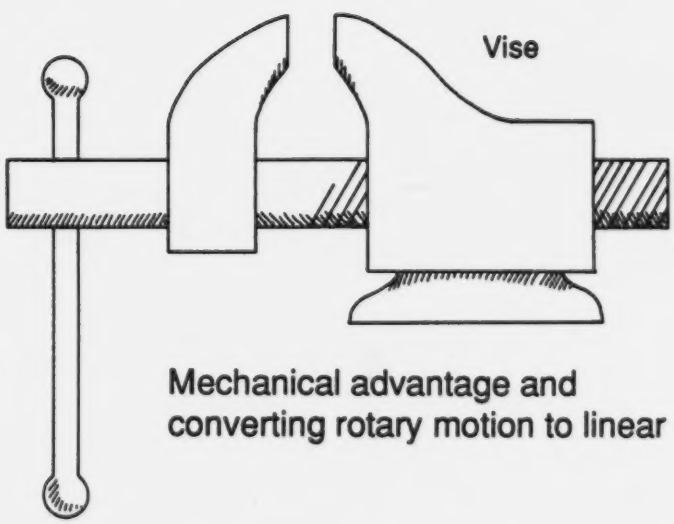
Nut and bolt

Fasteners



Micrometer

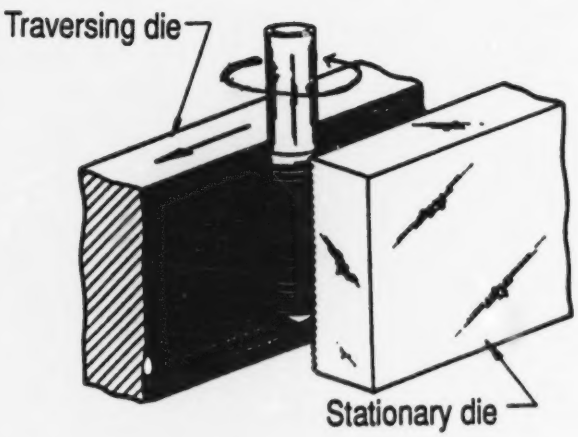
Precision measurement



Vise

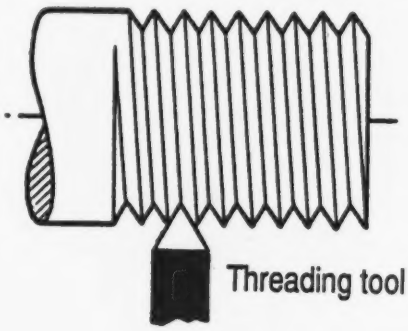
Mechanical advantage and converting rotary motion to linear

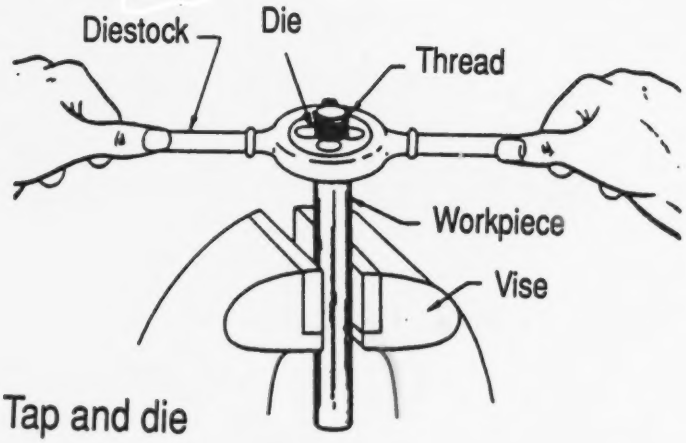
SCREW THREAD MANUFACTURE



Thread rolling

Single-point on lathe





Tap and die

Credit: Metalwork Technology and Practice (from the 1989 or earlier editions of this book). Reproduced with permission of the publisher, Glencoe Publishing Company, Mission Hills, Calif. All rights reserved.

MODULE: BENCH WORK AND MATERIAL SCIENCE

UNIT IV: CUTTING THREADS WITH TAP AND DIE

LESSON 2: THREAD NOMENCLATURE AND SPECIFICATIONS

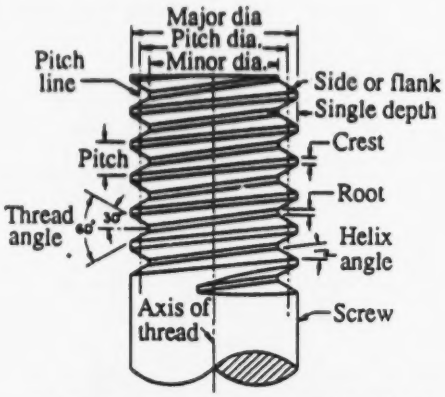
I. Thread nomenclature (parts)

A. Major diameter--largest width on a straight external or internal thread

B. Minor diameter--smallest width on a straight internal or external thread

C. Crest--top surface which joins two sides of a thread. It is the major diameter on an external thread and the minor diameter on an internal thread.

D. Root--bottom surface joining the sides of a screw thread. It is the minor diameter on an external thread and the major diameter on an internal thread.



Credit: Metalwork Technology and Practice (from the 1989 or earlier editions of this book). Reproduced with permission of the publisher, Glencoe Publishing Company, Mission Hills, Calif. All rights reserved.

E. Pitch--linear distance from one point on a thread to the corresponding point on the next thread such as the distance from crest to crest on two adjacent threads. For the Unified thread series, it is the number of threads per inch.

F. Lead--linear distance a screw will travel in one revolution. It is equal to the pitch. In the Unified thread series, it is equal to the reciprocal of the number of threads per inch.

G. Thread angle--included angle between two sides of adjacent threads

H. Helix angle (also lead angle)--angle formed by helix of thread measured perpendicular to the axis of the thread

II. Thread specifications **(HO 2.1, 2.2)**

A. Thread form or profile

1. ISO metric threads--international standard for metric threads

a. Three classes (only coarse series is in common use for fasteners)

b. Specified as M for metric; diameter x pitch

Example: M8 x 1.25 means a metric thread with a diameter of 8 mm and a pitch of 1.25 mm.

c. 60° angle of thread

2. Unified National thread--screw thread standard developed for use in U.S. and Canada in 1948

a. 60° angle of thread

b. All dimensions in inches

c. Three series in common use: Unified National Coarse (UNC); Unified National Fine (UNF); and Unified National Extra-Fine (UNEF)

d. Specified by diameter, pitch, series, class of fit, (tolerance), external (A) or internal (B) and LH if thread is left-handed (advances when turned counterclockwise)

Example: 3/4-10 UNC-3A-LH

3. Acme thread--used on lead screws in machine tools, vises and jack screws or any application requiring transfer of motion

a. 29° angle of thread

b. Specified by diameter and pitch (number of threads per inch)

4. Pipe thread--based on American Standard Pipe Thread (NPT)

a. Threads are formed on a tapered diameter to provide the capability of sealing joints in a pipe that is transporting fluids.

b. Threads have a 60° angle.

c. The taper on the pipe is 3/4" per foot (difference between small and large ends if the taper were a foot long).

d. Pipe threads are specified by diameter and pitch.

e. The diameter generally indicates the inside diameter of the pipe.

B. Thread class--refers to the tolerance or tightness of fit of the mating parts of a thread

1. Metric thread classes

a. For external threads there are three fit designations: e = large allowance; g = small allowance and h = no allowance.

b. For internal threads there are two fit designations: G = small allowance and H = no allowance.

2. There are three external and three internal Unified thread classes.

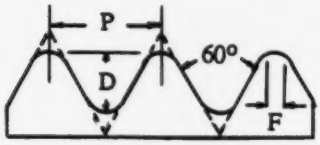
a. 1A and 1B--used where a fit with considerable play or looseness is desired

b. 2A and 2B--used on most commercial fasteners. Some allowance between parts is provided.

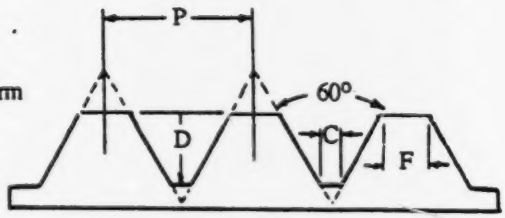
c. 3A and 3B--close fit used when extreme accuracy is required

THREAD FORMS

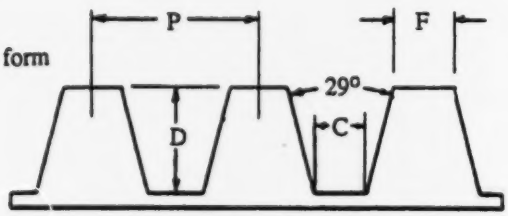
Unified thread form



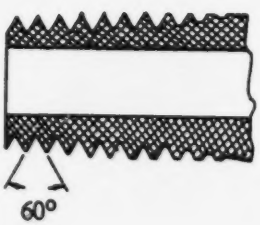
International metric thread form



Acme thread form

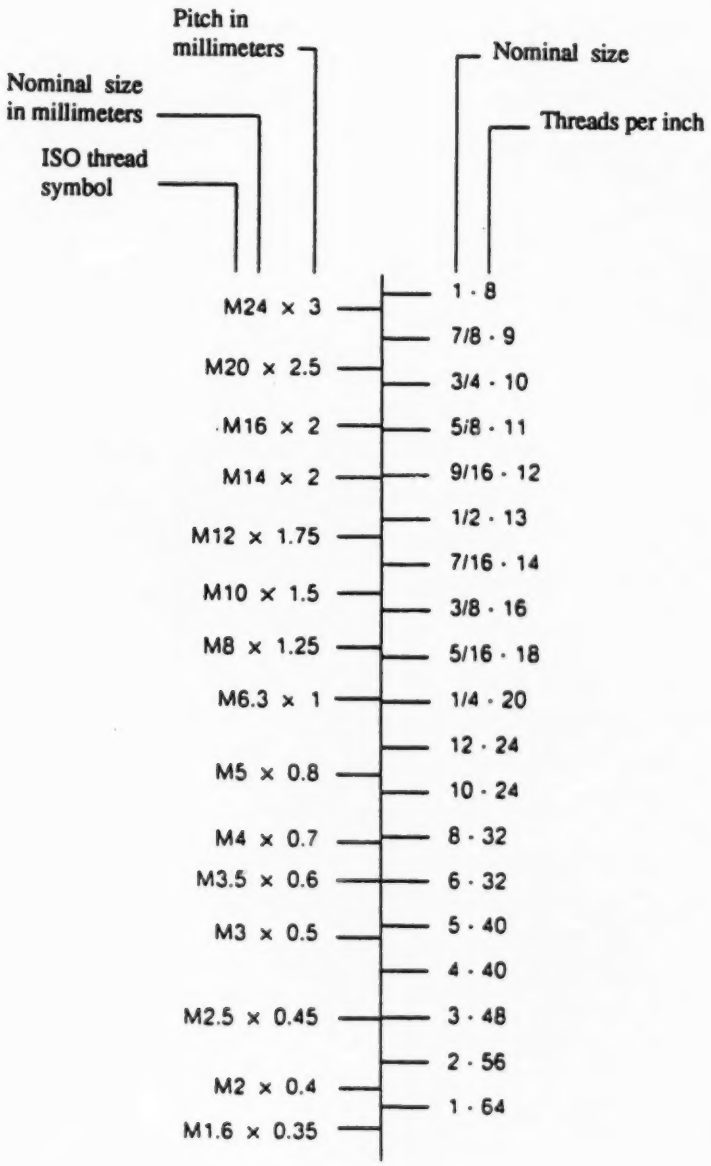


Pipe threads (NPT)



Credit: Krar, S. F. and J. W. Oswald. Turning Technology. Albany, NY: Delmar, © 1971, pg. 121, 122. Reproduced by permission.

COMPARISON OF COMMON ISO METRIC AND UNIFIED THREADS



Credit: Metalwork Technology and Practice (from the 1989 or earlier editions of this book). Reproduced with permission of the publisher, Glencoe Publishing Company, Mission Hills, Calif. All rights reserved.

MODULE: BENCH WORK AND MATERIAL SCIENCE

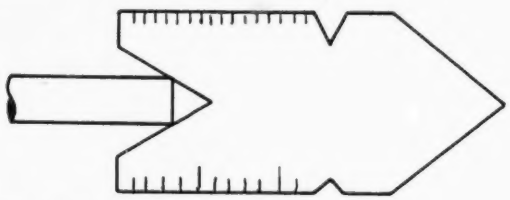
UNIT IV: CUTTING THREADS WITH TAP AND DIE

LESSON 3: THREAD MEASUREMENT

I. Measuring angle of Unified, metric and Acme threads **(TM 3.1)**

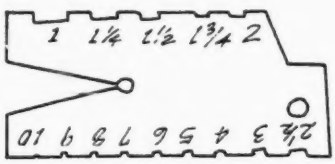
A. Angle measurement with a center gage

1. A center gage is used as a guide when grinding a lathe tool used to cut metric or Unified series threads.



2. A combination set protractor can also be used.

B. Acme thread gage

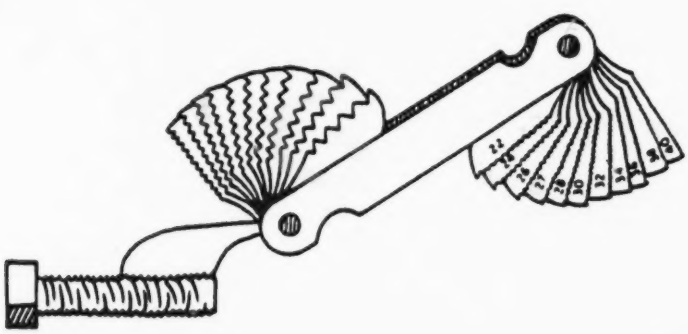


1. Used to measure angle of thread when grinding lathe tool

2. Also used to measure correct width of tool bit end

II. Measuring pitch and diameter

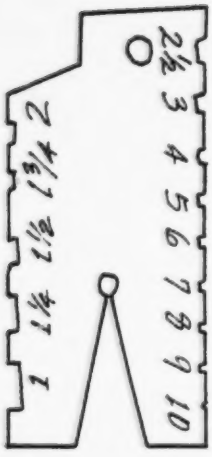
A. A screw pitch gage has multiple "leaves" for comparing pitch of metric and National threads.



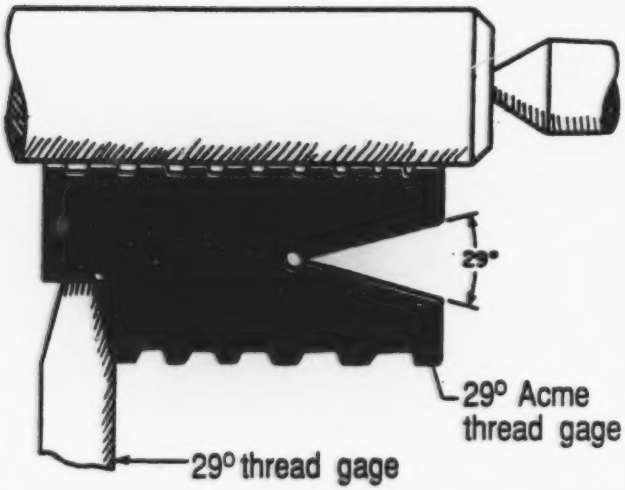
B. A steel rule can also be used to measure pitch. (The number of threads are counted per a given length.)

C. To measure diameter, use a micrometer or vernier caliper.

ACME THREAD MEASUREMENT GAGES



Acme standard
29° thread



The toolbit is squared with work
by an Acme thread gage.

Credit: Adapted from Krar, S. F. and J. W. Oswald. Turning Technology. Albany, NY: Delmar, © 1971, fig. 21-15. Reproduced by permission.

MODULE: BENCH WORK AND MATERIAL SCIENCE

UNIT IV: CUTTING THREADS WITH TAP AND DIE

LESSON 4: CUTTING THREADS WITH A DIE

NOTE: Select a die according to desired diameter and pitch.

I. Cutting threads

A. Workpiece preparation

1. The end of the workpiece to be threaded will need to be slightly chamfered so the die can start properly.

2. This is accomplished on the pedestal grinder.

NOTE: If the student has not been instructed on the safe use of the pedestal grinder, the instructor could demonstrate chamfering of a workpiece in this lesson.

B. Work holding

1. A round workpiece has a tendency to turn in the vise.

2. Consider the need for force sufficient to hold the workpiece but not enough to mar the workpiece surface. Use soft copper jaws on the vise.

C. Using a die and diestock **(HO 1.1)**

CAUTION: A die is a hardened cutting tool usually made of high-speed steel that may be subject to breakage even under normal use. Safety glasses must be worn when threading with a die.

1. If the die is adjustable, it should be adjusted to fit a standard bolt of the same specification as the thread to be cut.

2. The die should mount securely in the diestock.

3. Most dies have a tapered side, which is the starting side. This side should be used to start the die on the end of the workpiece.

4. The die must be kept perpendicular (square) to the workpiece.

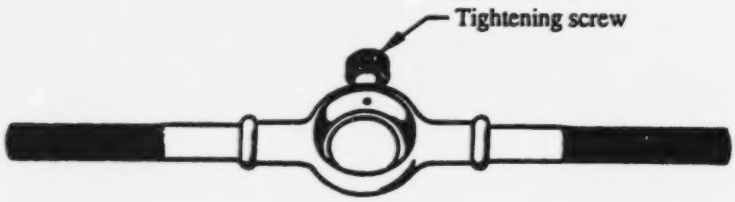
   a. Firm, even pressure must be applied as the die is turned.

   b. Once started, the die will screw itself onto the workpiece.

5. An appropriate cutting fluid may be used.

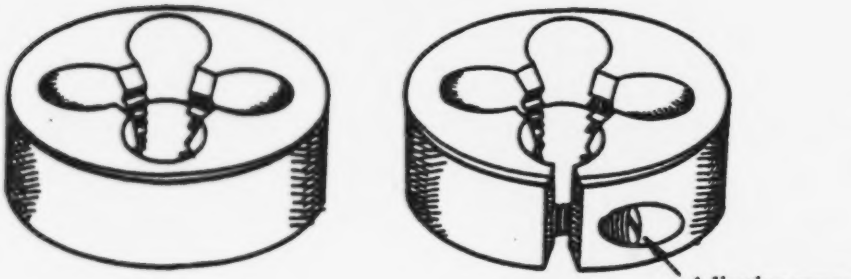
6. The die should be reversed every two or three threads to permit chips to break free.

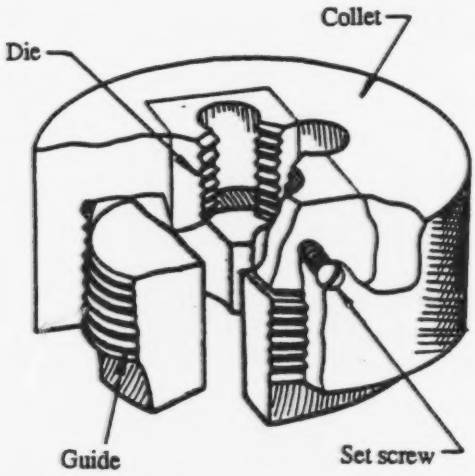
DIE PARTS AND DIESTOCK



A diestock

THREADING DIES

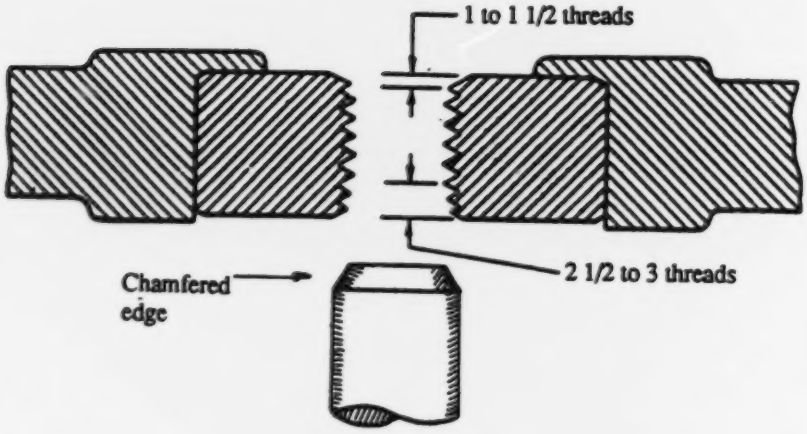


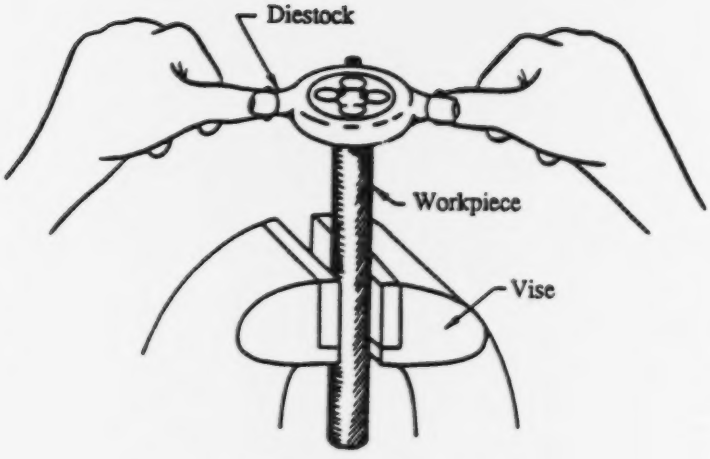


AN ADJUSTABLE DIE WITH REPLACEABLE CUTTERS

Credit: Metalwork Technology and Practice (from the 1989 or earlier editions of this book). Reproduced with permission of the publisher, Glencoe Publishing Company, Mission Hills, Calif. All rights reserved.

STARTING A DIE





Credit: Metalwork Technology and Practice (from the 1989 or earlier editions of this book). Reproduced with permission of the publisher, Glencoe Publishing Company, Mission Hills, Calif. All rights reserved.

CUT EXTERNAL THREADS WITH A DIE

Equipment:

Diestock
1/2-13 UNC adjustable die
Bench vise on bench (soft jaws)
12" length of 1/2" diameter cold-rolled mild steel
Safety glasses
Bench rule
Scriber
Sulfurized mineral oil cutting fluid (dark threading oil)
1/2-13 UNC bolt and nut
Wire brush

Procedure:		Evaluation 3	2	1	N
1.	Chamfer the end of the workpiece on the pedestal or bench grinder.	—	—	—	—
	NOTE: Ask the instructor to demonstrate the use of the pedestal grinder if you have not received instruction on its use before.				
2.	Secure workpiece in vise.	—	—	—	—
3.	Mark off length to be threaded (3").	—	—	—	—
4.	Adjust the die to fit a standard bolt of the same thread as that which you are preparing to cut.	—	—	—	—
5.	Mount the die in the diestock.	—	—	—	—
6.	Place a few drops of lubricant on the workpiece where it is to be threaded.	—	—	—	—
7.	Start tapered side of die on chamfered end of workpiece. Check squareness.	—	—	—	—
8.	Press down firmly and turn the die one full turn to start the thread.	—	—	—	—
9.	Continue cutting until a 3" length of the rod has been threaded. Reverse the direction of the die every 2-3 threads to break chips. Apply additional cutting fluid as needed.	—	—	—	—
10.	Clean thread with a wire brush to remove chips and debris. Attempt to turn nut onto the thread. If nut will not go easily, remove die from diestock and adjust to cut deeper. Repeat steps 6-10.	—	—	—	—
11.	As directed by instructor, prepare for next job sheet or clean up area and return tools and materials.	—	—	—	—
Average of above evaluations*		—	—	—	—

*This average is the student's final evaluation for competency E6: Cut threads with die.

MODULE: BENCH WORK AND MATERIAL SCIENCE

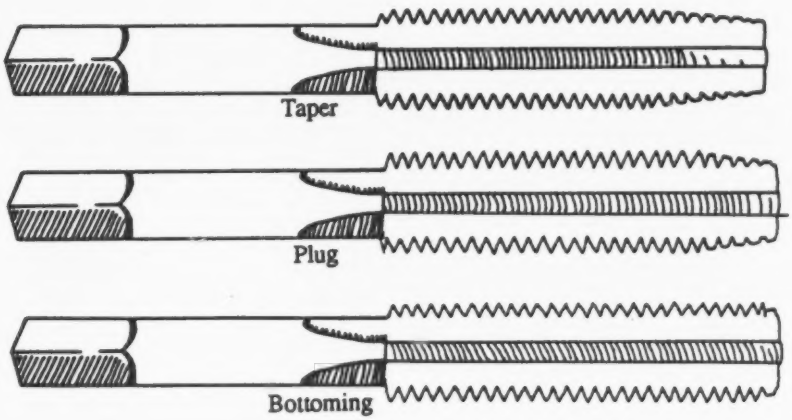
UNIT IV: CUTTING THREADS WITH TAP AND DIE

LESSON 5: CUTTING INTERNAL THREADS WITH A TAP

I. Tap specifications

A. Types

1. Taper--used to start the threaded hole
2. Plug--used to start threads on easy tapping materials
3. Bottoming--used to cut threads all the way to the bottom of a blind hole (has full threads on the end)



B. Styles

1. Straight flute
2. Helical or spiral flute

C. Same sizes as bolts

1. ISO metric
2. Unified series

D. Tap drills (HO 5.1)

1. A hole to be tapped must be the right size.
2. Recommended tap drills produce about 75% thread.
3. Use the tap drill chart to select the correct tap.

II. Cutting threads with a tap

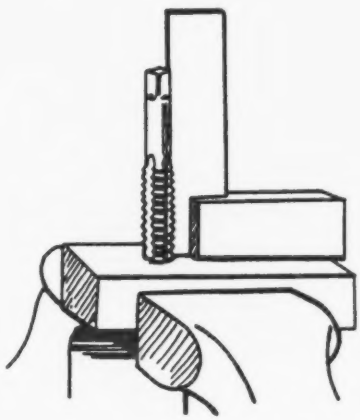
CAUTION: A tap is a hardened cutting tool usually made of high-speed steel which may be subject to breakage even under normal use. Safety glasses must be worn when threading with a tap.

A. A hole made with the proper tap drill must be provided.

B. To start the threads, use a taper or plug tap installed in a tap wrench.

C. Grasp the tap wrench with both hands close to the tap. Press down firmly while turning the tap clockwise into the drilled hole.

D. The tap must be started and maintained in a perpendicular position throughout the threading operation. The squareness of the tap with the workpiece must be checked periodically with a small square or steel rule.



E. Once the tap has been started, it is no longer necessary to apply downward pressure. Hands can be shifted to the ends of the tap wrench to provide the twisting force necessary to drive the tap into the workpiece.

F. Reverse wrench direction by one-half a turn every 2-3 threads to permit chips to break. A few drops of an appropriate cutting fluid should be applied.

NOTE: Taps of 1/4" or smaller in diameter can break easily. It is important to apply only twisting action. If the wrench is leaned in one direction or the other, the tap is likely to break.

G. Blind holes must be finished with a bottoming tap to permit cutting of threads to the bottom of the hole.

TAP DRILL CHART

HO 5.1

FRACTION OR DRILL SIZE	DECIMAL EQUIVALENT	TAP SIZE
NUMBER SIZE DRILLS 80	.0135	
NUMBER SIZE DRILLS 79	.0145	
1/64	.0156	
78	.0160	
77	.0180	
76	.0200	
75	.0210	
74	.0225	
73	.0240	
72	.0250	
71	.0260	
70	.0280	
69	.0292	
68	.0310	
1/32	.0312	
67	.0320	
66	.0330	
65	.0350	
64	.0360	
63	.0370	
62	.0380	
61	.0390	
60	.0400	
59	.0410	
58	.0420	
57	.0430	
56	.0465	
3/64	.0469	0 - 80
55	.0520	
54	.0550	
53	.0595	1 - 64, 72
1/16	.0625	
52	.0635	
51	.0670	
50	.0700	2 - 56, 64
49	.0730	
48	.0760	
5/64	.0781	
47	.0785	3 - 48
46	.0810	
45	.0820	3 - 56
44	.0860	
43	.0890	4 - 40
42	.0935	4 - 48
3/32	.0938	
41	.0960	
40	.0980	
39	.0995	
38	.1015	5 - 40
37	.1040	5 - 44
36	.1065	6 - 32
7/64	.1094	
35	.1100	
34	.1110	
33	.1130	6 - 40
32	.1160	
31	.1200	
1/8	.1250	
30	.1285	
29	.1360	8-32, 36
28	.1405	
9/64	.1406	
27	.1440	
26	.1470	
25	.1495	10 - 24
24	.1520	
23	.1540	
5/32	.1562	
22	.1570	
21	.1590	10 - 32
20	.1610	
19	.1660	
18	.1695	
11/64	.1719	
17	.1730	
16	.1770	12 - 24
15	.1800	
14	.1820	12 - 28
13	.1850	
3/16	.1875	
12	.1890	
11	.1910	
10	.1935	
9	.1960	
8	.1990	
7	.2010	1/4 - 20
13/64	.2031	
6	.2040	
5	.2055	
4	.2090	
3	.2130	1/4 - 28
7/32	.2188	
2	.2210	
LETTER SIZE DRILLS 1	.2280	
LETTER SIZE DRILLS A	.2340	
15/64	.2344	
LETTER SIZE DRILLS B	.2380	
C	.2420	
D	.2460	
1/4 — E	.2500	
F	.2570	5/16 - 18
G	.2610	
17/64	.2656	
H	.2660	
I	.2720	3/8 - 24
J	.2770	
K	.2810	
9/32	.2812	
L	.2900	
M	.2950	
19/64	.2969	
N	.3020	
5/16 — O	.3125	3/8 - 16
P	.3160	
21/64	.3230	
Q	.3281	
R	.3320	3/8 - 24
11/32	.3390	
S	.3438	
T	.3480	
23/64	.3580	
U	.3594	
3/8 — V	.3680	7/16 - 14
W	.3750	
25/64	.3770	
X	.3860	
Y	.3906	7/16 - 20
13/32	.3970	
Z	.4040	
27/64	.4062	
7/16	.4130	1/2 - 13
29/64	.4219	
15/32	.4375	1/2 - 20
31/64	.4531	
1/2	.4688	9/16 - 12
33/64	.4844	
17/32	.5000	9/16 - 18
35/64	.5156	5/8 - 11
9/16	.5312	
37/64	.5469	
19/32	.5625	5/8 - 18
39/64	.5781	
5/8	.5906	
41/64	.6094	
21/32	.6250	
43/64	.6406	
11/16	.6562	3/4 - 10
45/64	.6719	
23/32	.6875	3/4 - 16
47/64	.7031	
3/4	.7188	
49/64	.7344	
25/32	.7500	7/8 - 9
51/64	.7656	
13/16	.7812	
53/64	.7969	7/8 - 14
27/32	.8125	
55/64	.8281	
7/8	.8438	
57/64	.8594	1 - 8
29/32	.8750	
59/64	.8906	
15/16	.9062	1 - 12
61/64	.9219	
31/32	.9375	
63/64	.9531	
1	.9688	
1 1/64	.9844	1 1/8 - 7
1 3/64	1.0000	
1 7/64	1.0469	1 1/4 - 12
1 1/8	1.1094	1 1/4 - 7
1 11/64	1.1250	
1 7/32	1.1719	1 3/8 - 12
1 1/4	1.2188	1 3/8 - 6
1 19/64	1.2500	
1 11/32	1.2969	1 1/2 - 12
1 3/8	1.3438	1 1/2 - 6
1 27/64	1.3750	
1 1/2	1.4219	1 1/2 - 12
	1.5000	

PIPE THREAD SIZES

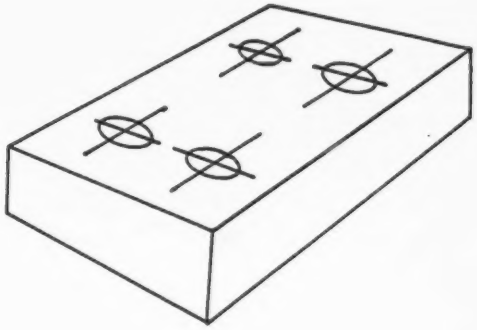
THREAD	DRILL	THREAD	DRILL
1/8 - 27	R	1 1/2 - 11 1/2	1 47/64
1/4 - 18	7/16	2 - 11 1/2	2 7/32
3/8 - 18	37/64	2 1/2 - 8	2 5/8
1/2 - 14	23/32	3 - 8	3 1/4
3/4 - 14	59/64	3 1/2 - 8	3 3/4
1 - 11 1/2	1 5/32	4 - 8	4 1/4
1 1/4 - 11 1/2	1 1/2		

Bench & Mat'l. Sci. 101

CUT INTERNAL THREADS WITH A TAP

Equipment:

Tap wrench (T-handle and flat)
Taper taps: 10-32, 1/4-20, 1/2-13, 3/4-10
Pre-drilled block of 6061-T6 aluminum as per drawing
Drilled holes, 1 ea., as follows:
#21, #7, 27/64, 21/32
Bench vise
Threading fluid for aluminum
Small square or steel rule
Screw pitch gage
0-1" micrometer
Vernier caliper
Tap drill chart



Procedure:	Evaluation 3	2	1	N
1. Check tap specifications by measuring diameter with the micrometer and pitch with the screw pitch gage.	—	—	—	—
2. Match taps with the correct tap dill hole by measuring hole diameters with the vernier caliper and comparing dimensions with the tap drill chart.	—	—	—	—
3. Mount the workpiece securely in the vise.	—	—	—	—
4. Install the 10-32 tap in the T-handle tap wrench.	—	—	—	—
5. Apply a few drops of cutting oil to the hole. Insert the tap in the hole. Press down firmly on the tap while turning it clockwise.	—	—	—	—
6. Check the tap with a square or steel rule to make certain that it has started squarely. If it has not, restart.	—	—	—	—
7. Cut several more threads. Apply additional cutting fluid. Reverse the direction of the tap one-half turn every 2-3 threads to permit chips to break.	—	—	—	—
8. When the threads have been cut through the workpiece, back the tap out of the hole carefully.	—	—	—	—
9. Repeat steps 4-8 for the remaining taps. Use the flat tap wrench for 1/2" and 3/4" taps.	—	—	—	—
10. Return equipment to its proper storage area.	—	—	—	—
Average of above evaluations*	—	—	—	—

*This average is the student's final evaluation for competency E7: Cut threads with hand tap.

MODULE: BENCH WORK AND MATERIAL SCIENCE

UNIT IV: CUTTING THREADS WITH TAP AND DIE

UNIT TEST

Select the option which best answers the question or completes the statement.

____ 1. Which of the following is a common use for screw threads?

a. Transmit motion
b. Provide mechanical advantage
c. Permit precision measurement
d. Fasteners
e. All of the above

____ 2. Which of the following is not a method of thread manufacture?

a. Rolling
b. Welding
c. Tap and die
d. Single-point
e. None of the above

____ 3. Which thread type is used for high-load applications such as machine tool lead screws and vises?

a. Acme
b. Unified
c. ISO metric
d. NPT
e. None of the above

____ 4. Which thread type is used to seal joints in fluid applications?

a. Acme
b. Unified
c. ISO metric
d. NPT
e. None of the above

____ 5. Which thread type is the accepted international standard for threaded devices?

a. Acme
b. Unified
c. ISO metric
d. NPT
e. None of the above

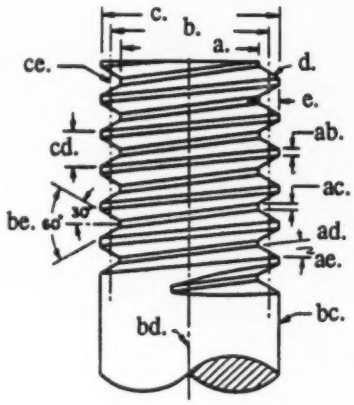
____ 6. What does a screw thread's class refers to?

a. Thread form
b. Fit between mating parts
c. Pitch
d. ISO metric
e. All of the above

___ 7. Which device would not be appropriate for measuring screw pitch?

a. Dial indicator
b. Vernier caliper
c. Pitch gage
d. Steel rule
e. None of the above

Match the thread parts with the letter indicated on the drawing.



___ 8. Major diameter

___ 9. Root

___ 10. Angle of thread

___ 11. Minor diameter

___ 12. Pitch

Questions 13-17 refer to the thread designation: 1/2-13 UNC-3A-LH. Select the option which best answers the question or completes the statement.

___ 13. What is the thread's diameter?

a. 13 millimeters
b. 1.2"
c. 1 3/4"
d. 1/2"
e. 13 units

___ 14. What is the thread's pitch?

a. 13
b. 1/2
c. 1.2
d. UNC
e. None of the above

___ 15. What does 3A refer to?

a. Class 3 fit on an external thread
b. Class 3 fit on an internal thread
c. Class 3A fit on a 13 mm screw
d. Right-hand thread
e. None of the above

___ 16. What type of thread is this?

a. Acme
b. Unified
c. ISO metric
d. NPT
e. None of the above

___ 17. In what direction would the screw turn to advance?

a. Clockwise
b. Counter-clockwise
c. Clockwise with double lead
d. Counter-clockwise with double lead
e. None of the above

___ 18. Which step is important when cutting threads with a die?

a. Chamfer the edge of the workpiece.
b. Use an appropriate cutting fluid.
c. Wear safety glasses.
d. Mount the workpiece in a vise or other work-holding device.
e. All of the above

___ 19. Which type of tap is used to create threads in a blind hole?

a. Plug
b. Bottoming
c. Taper
d. Straight flute
e. None of the above

___ 20. Which step is important when threading with tap?

a. Make sure the tap is started straight.
b. Use an appropriate cutting fluid.
c. Be certain the correct tap drill has been used to make the hole.
d. Apply only a turning force to the tap.
e. All of the above

ANSWERS TO UNIT TEST

1.	e		11.	a	
2.	b		12.	cd	
3.	a		13.	d	(E6, 7)
4.	d		14.	a	(E6, 7)
5.	c		15.	a	E6, 7)
6.	b		16.	b	(E6, 7)
7.	a	(E6, 7)	17.	b	(E6, 7)
8.	c		18.	e	(E6)
9.	ac		19.	b	(E7)
10.	be		20.	e	(E7)

MODULE: PERFORMING BENCH WORK

UNIT V: USING A HAND REAMER

UNIT OBJECTIVE

Upon completion of this unit, the student should be able to describe, select and properly use hand reamers. This knowledge will be evidenced by achieving the specified score on the job sheet and unit test.

SPECIFIC OBJECTIVES

Upon completion of the lesson in this unit, the student should be able to:

1.1 Describe hand reamer uses, construction, types, classes and sizes.

1.2 Ream holes with hand reamer. (competency E8, JS 1.1)

MODULE: PERFORMING BENCH WORK

UNIT V: USING A HAND REAMER

CONTENTS OF THIS UNIT

A. Objective sheet

B. References

C. Notes to the instructor

D. Lesson plan

1. Lesson 1: HAND REAMING

   a. Information outline

   b. Transparency master

      TM 1.1: Hand reamer positioned for use

   c. Job sheet

      JS 1.1: Ream holes with hand reamer

E. Unit test

F. Answers to unit test

REFERENCES

A. Books

1. Repp, Victor E., and Willard J. McCarthy. Machine Tool Technology. 5th ed. Bloomington, IL: McKnight Publishing Co., 1984.

2. Repp, Victor E., Willard J. McCarthy and Oswald A. Ludwig. Metalwork Technology and Practice. Bloomington, IL: McKnight Publishing Co., 1982.

B. Curriculum guide

1. Benson, Robert T., and Margaret R. Gregory. V-TECS Guide for Machine Shop. Columbia, SC: South Carolina Department of Education, 1985.

MODULE: PERFORMING BENCH WORK

UNIT V: USING A HAND REAMER

LESSON 1: HAND REAMING

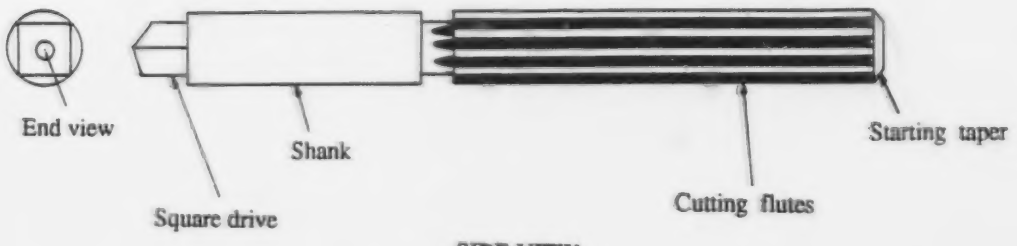
I. Description of a hand reamer

A. Uses

1. Hole finishing tool that is used when accuracy is required
    a. Improves dimensional accuracy
    b. Improves roundness of hole
    c. Improves straightness of hole
    d. Improves surface finish inside of hole
2. Primarily used to create holes to accommodate dowel pins
3. Specialized application: taper pins

B. Construction

1. Material
    a. Carbon-tool steel
    b. High-speed steel
    c. Carbide tipped
2. Features
    a. Shank
    b. Square drive end for mounting in tap wrench
    c. Flutes (straight or helical)
    d. Starting taper
    e. 60° ground center hole that will receive lathe center held in drill press



SIDE VIEW

C. Types

1. Machine or chucking reamer

   a. Used for production operations

   b. Held in machine with collet or chuck

2. Hand reamer

   a. Used when accuracy is required

   b. Turned by hand with a tap wrench

   c. Has a square shank end for tap wrench drive

   d. Has a small start taper on the flutes

D. Classification of hand reamers

1. Straight fluted

2. Expansion straight flute

3. Adjustable

4. Helical flute

5. Taper pin

E. Sizes (specified by diameter at flutes)

1. Inch--based on standard dowel pin sizes, fractional sizes; 1/16" to 1"

2. Metric--based on standard dowel pin sizes; commonly M3-M8 in one mm increments

3. Taper pin--numbered pin sizes for Brown and Sharpe standard tapers

II. Hand reaming tips and techniques **(TM 1.1)**

CAUTION: Wear safety glasses when using a hand reamer.

A. Hole preparation

1. Drill a hole 1/64" less than the desired size.

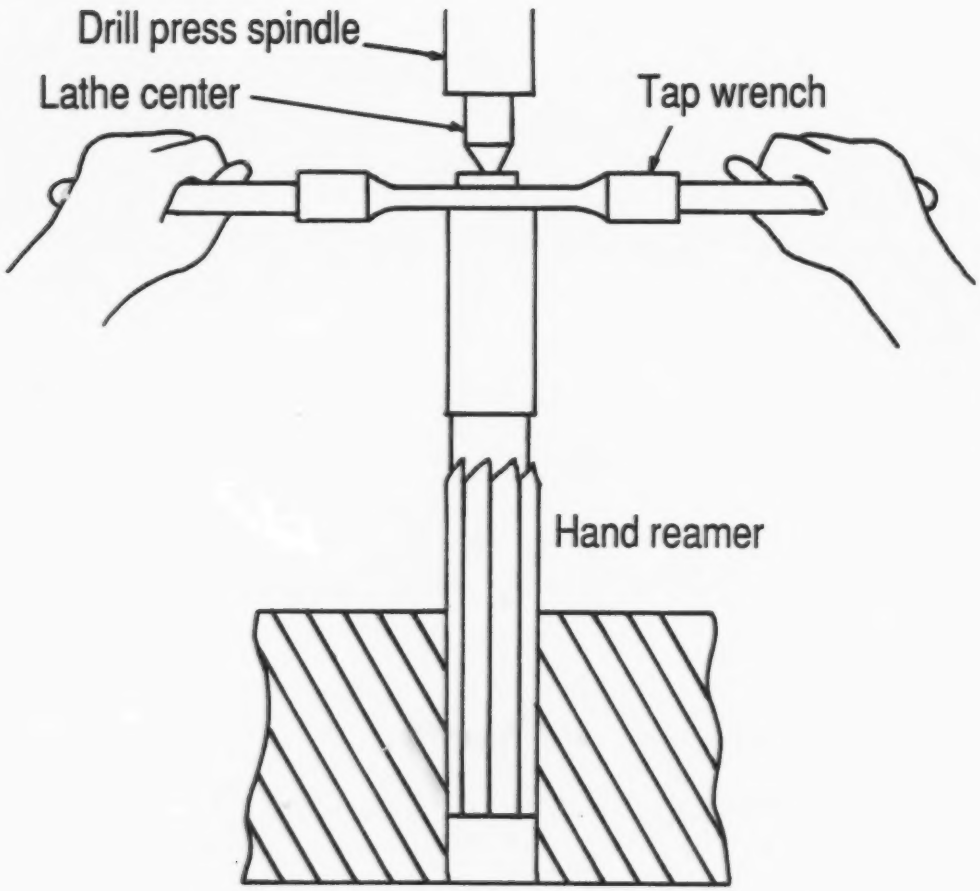
2. Never attempt to remove more than 1/64" (0.015") with a hand reamer. Generally, only 0.005" excess material is left in the hole to be removed by hand reaming.

B. Use a lathe center held in the drill press to assure straightness, applying a minimum of pressure.

C. Use an appropriate cutting fluid.

D. Turn the reamer slowly with a flat tap wrench. Turn in the direction of cutting even when removing the reamer.

HAND REAMER POSITIONED FOR USE

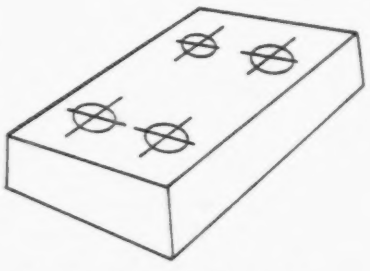


REAM HOLES WITH HAND REAMER

Equipment:

1/2" carbon or high-speed steel hand reamer with straight-flute
Flat tap wrench
Drill press with vise
60° lathe center with taper shank to fit drill press spindle taper
Cutting fluid for aluminum
Aluminum workpiece with four drilled holes bored to 0.498" (See drawing.)
Safety glasses

4 holes drill and bore 0.498"



CAUTION: Reamers are made from hard, brittle material and can break easily. They should never be struck against another object or used for any purpose other than for reaming holes. Safety glasses must be worn when using a reamer.

Procedure:	Evaluation 3	2	1	N
1. Install lathe center in drill press spindle taper. (If you have not received instruction on drill press operation, ask the instructor for assistance.)	—	—	—	—
2. Install reamer in the tap wrench.	—	—	—	—
3. Mount the workpiece in the vise. Do not secure vise to drill press table. Allow for clearance under the workpiece.	—	—	—	—
4. Place reamer's taper end in the workpiece hole. Adjust the position of the vise and workpiece until the reamer shank center hole will receive the lathe center.	—	—	—	—
5. Lock down the drill press spindle so that the lathe center is engaged into the end of the reamer.	—	—	—	—
CAUTION: Do <u>not</u> turn on the drill press under any circumstances!				
6. Secure the vise to the drill press table.	—	—	—	—
7. Apply a few drops of cutting fluid to the reamer and hole. Turn the reamer clockwise with downward pressure. Continue turning until the entire length of the hole has been reamed.	—	—	—	—
8. Release the drill press spindle. Remove the reamer by turning clockwise and pulling up slightly.	—	—	—	—
9. Clean workpiece and submit to the instructor.	—	—	—	—
10. Clean up area and return tools and materials.	—	—	—	—
Average of above evaluations*	—	—	—	—

*This average is the student's final evaluation for competency E8: Ream holes with hand reamer.

MODULE: PERFORMING BENCH WORK

UNIT V: USING A HAND REAMER

UNIT TEST

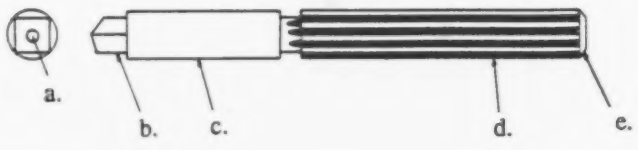
Find the corresponding letter in the illustration for each of the parts listed.

____ 1. Shank

____ 2. Drive end

____ 3. Flutes

____ 4. Starting taper



Choose the option which best answers the question or completes the statement.

____ 5. Which of the following is <u>not</u> a reason for using a reamer?

a. To remove a great amount of material quickly
b. To improve dimensional accuracy
c. To improve the straightness of a hole
d. To enhance a hole's surface finish
e. None of the above

____ 6. One specialized application of reamers is to accommodate _____ .

a. Bolts
b. Taper pins
c. Washers
d. Castle nuts
e. None of the above

____ 7. Which is a type of hand reamer?

a. Expansion
b. Adjustable
c. Straight flute
d. Helical flute
e. All of the above

____ 8. What is the maximum amount to be removed with a hand reamer?

a. 0.005"
b. 0.002"
c. 1/64"
d. 1/32"
e. 1/24"

___ 9. Which item us not essential for starting a reamer straight and true?

a. Drill press
b. Lathe center
c. Drill press vise
d. Reamer's 60° center hole
e. Tap handle

___ 10. The square end of the reamer provides a drive for which of the following tools?

a. Adjustable wrench
b. Socket wrench
c. Adjustable pliers
d. Flat tap wrench
e. None of the above

___ 11. When the reaming operation is complete, how is the reamer removed?

a. Pull the reamer slowly out of the hole.
b. Reverse the direction of the reamer and pull up lightly.
c. Release the reamer and let it drop through the hole.
d. Continue to turn it in a clockwise direction while pulling it up lightly.
e. Turn in a counter-clockwise direction and pull up lightly.

ANSWERS TO UNIT TEST (E8)

1. c
2. b
3. d
4. e
5. a
6. b
7. e
8. c
9. c
10. d
11. d

MODULE: BENCH WORK AND MATERIAL SCIENCE
UNIT VI: PEDESTAL/BENCH GRINDER OPERATION

UNIT OBJECTIVE

Upon completion of this unit, the student should be able to identify the components and specifications of grinding wheels and utility grinders, dress and true grinding wheels, and grind and shape tools. This knowledge will be evidenced by achieving the specified score on job sheets and the unit test.

SPECIFIC OBJECTIVES

After completion of the lessons in this unit, the student should be able to:

1.1 Describe the components of a grinding wheel.

1.2 Identify reasons for grinding operations.

1.3 Identify grinding wheel specifications.

1.4 Describe the standard marking system for grinding wheels.

2.1 Distinguish between two common types of grinders.

2.2 Identify parts of an utility grinder.

3.1 Change a grinding wheel. (competency E9, JS 3.1)

3.2 Identify reasons for dressing and truing a grinding wheel.

3.3 List rules for safe grinder operation.

3.4 Dress and true grinding wheels on pedestal/bench grinder. (competency E9, JS 3.1)

4.1 Identify tools that can be sharpened on a grinder.

4.2 Define "burning the temper."

4.3 Sharpen a cold chisel. (competency E10, JS 4.1)

5.1 Describe a lathe toolbit.

5.2 Grind a lathe toolbit. (competency E10, JS 5.1)

6.1 Describe precision grinders.

6.2 Identify applications of hand grinders.

6.3 Grind using appropriate hand grinder. (competency E12, JS 6.1)

MODULE: BENCH WORK AND MATERIAL SCIENCE

UNIT VI: PEDESTAL/BENCH GRINDER OPERATION

CONTENTS OF THIS UNIT

A. Objective sheet

B. References

C. Notes to the instructor

D. Lesson plans

1. Lesson 1: GRINDING AND GRINDING WHEELS

   a. Information outline

   b. Handout

      HO 1.1: Standard marking system for grinding wheels

2. Lesson 2: GRINDER DESCRIPTION

   a. Information outline

3. Lesson 3: PREPARATION FOR GRINDING

   a. Information outline

   b. Job sheet

      JS 3.1: Dress and true grinding wheels on pedestal/bench grinder

4. Lesson 4: SHARPENING A COLD CHISEL

   a. Information outline

   b. Job sheet

      JS 4.1: Sharpen a cold chisel

5. Lesson 5: GRINDING A LATHE TOOLBIT

   a. Information outline

   b. Transparency master

      TM 5.1: Steps in toolbit grinding

   c. Handout

      HO 5.1: Lathe toolbit geometry

   d. Job sheet

JS 5.1: Grind a lathe toolbit

6. Lesson 6: HAND GRINDERS

a. Information outline

b. Transparency master

TM 6.1: Tooling for precision die grinders

c. Job sheet

JS 6.1: Grind using appropriate hand grinder

E. Unit test

F. Answers to unit test

REFERENCES

A. Books

1. Krar, S. F. and J. W. Oswald. Turning Technology. Albany, NY: Delmar, 1971.

2. Repp, Victor E., Willard J. McCarthy and Oswald A. Ludwig. Metalwork Technology and Practice. Bloomington, IL: McKnight Publishing Co., 1982.

B. Curriculum guides

1. Benson, Robert T., and Margaret R. Gregory. V-TECS Guide for Machine Shop. Columbia, SC: South Carolina Department of Education, 1985.

2. Grinder (student material #8045). College Station: Instructional Materials Service, Texas A & M University, 1984.

MODULE: BENCH WORK AND MATERIAL SCIENCE

UNIT VI: PEDESTAL/BENCH GRINDER OPERATION

LESSON 1: GRINDING AND GRINDING WHEELS

I. Grinding wheels are abrasive tools for machining metals. A grinding wheel has two components.

A. Abrasive--a very tough, hard material. When it is crushed into small particles, many sharp cutting edges are produced.

1. There are two common types of abrasive material.

a. Aluminum oxide

b. Silicon carbide

2. Particles are graded by passing them through sieves or screens to determine sizing.

Abrasive grain sizes for grinding wheels

Coarse	Medium	Fine	Very Fine
10	30	70	220
12	36	80	240
14	46	90	280
16	54	100	320
20	60	120	400
24		150	500
		180	600

B. Bonding material--cement which binds the abrasive particles together

1. Earth or clay (vitrified)

2. Silicate

3. Resin

4. Rubber or reinforced bond

II. Reasons for grinding

A. Sharpens cutting edges

1. Drills

2. Lathe tools

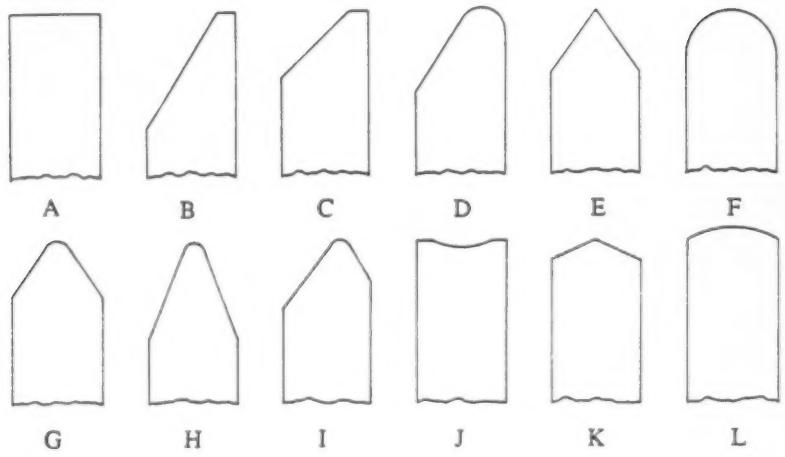
3. Chisels, etc.

B. Economical process for cutting very hard materials

C. Produces a fine surface finish

III. Ordering or descriptive specifications of grinding wheels

A. Shape



B. Type

C. Wheel diameter

D. Wheel thickness (width)

E. Arbor hole diameter

F. Speed of machine (rpm)

CAUTION: Speed is particularly important when selecting a grinding wheel. If the rated speed of the wheel is exceeded, it can fly to pieces. Always match the rpm rating of the grinder motor with the rating of the wheel.

G. Other information

1. Type of abrasive
2. Grain
3. Grade
4. Bond

IV. Standard marking system for identifying grinding wheels **(HO 1.1)**

A. Type of abrasive material

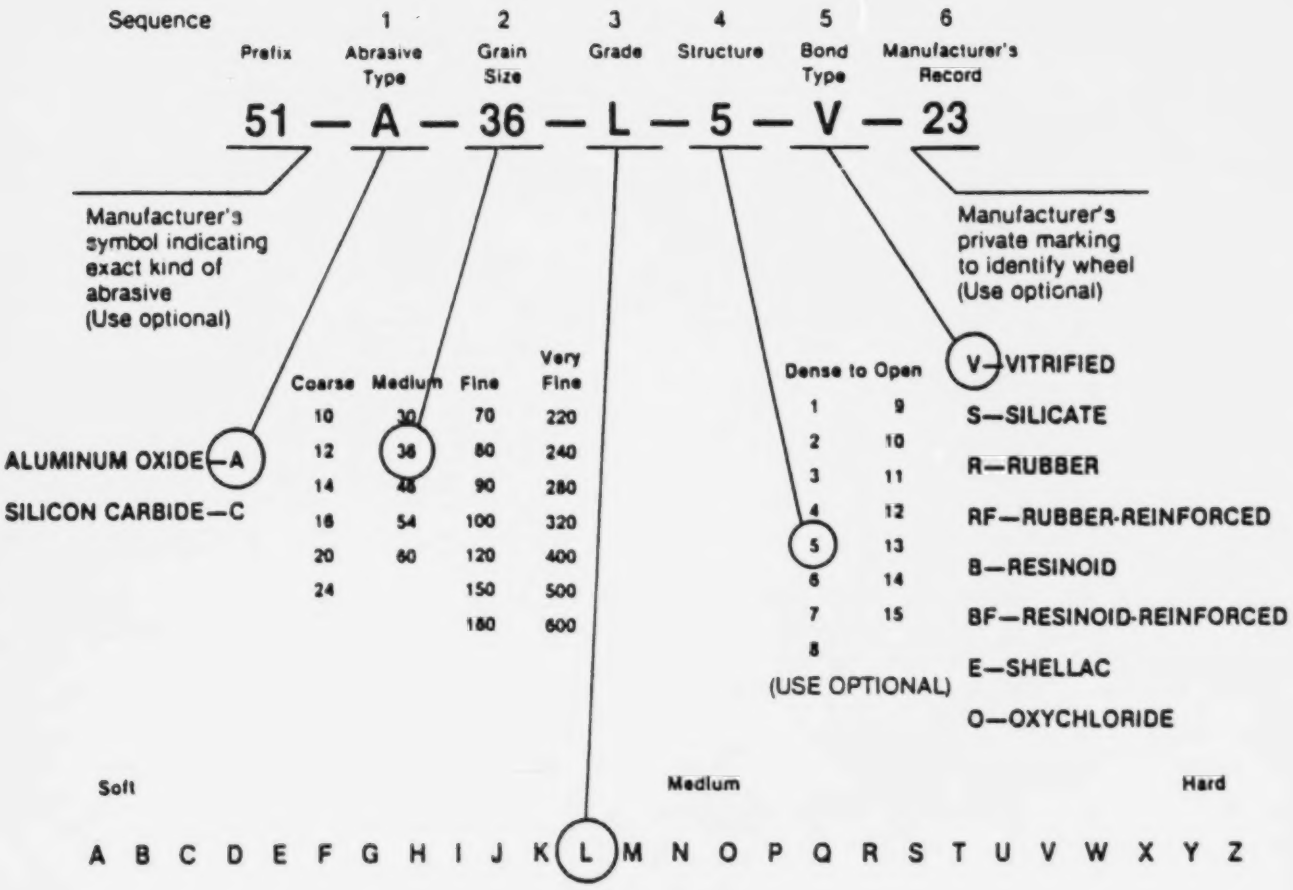
B. Grain size

C. Grade--relative hardness or softness

D. Structure--open or dense

E. Bond type wheel

STANDARD MARKING SYSTEM FOR GRINDING WHEELS



Based on ANSI B74.13-1982 (American National Standard Markings for Identifying Grinding Wheels and Other Bonded Abrasives). Copies of B74.13 are available from ANSI, 1430 Broadway, New York, NY 10018.

Bench & Mat'l. Sci. 131

MODULE: BENCH WORK AND MATERIAL SCIENCE

UNIT VI: PEDESTAL/BENCH GRINDER OPERATION

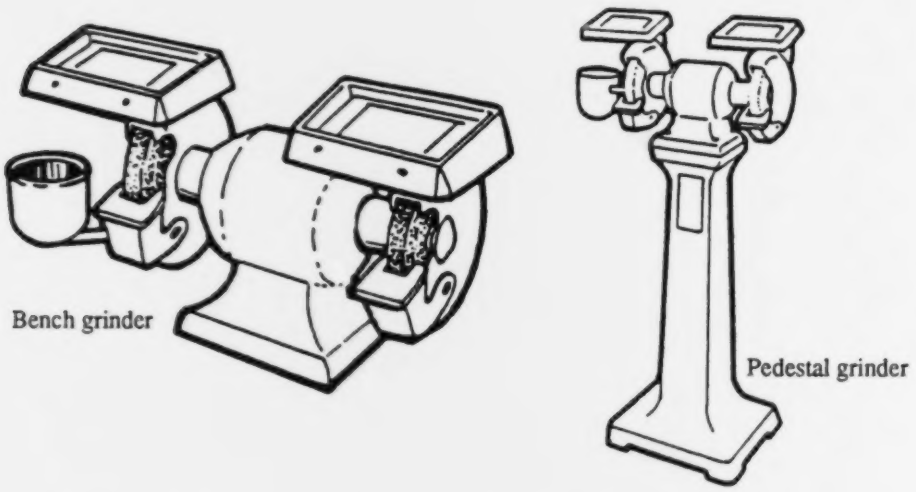
LESSON 2: GRINDER DESCRIPTION

I. Utility grinders

A. Utility grinders are essentially a motor with a shaft extending from both ends which holds a grinding wheel.

B. One common type, the bench grinder, is a small utility grinder mounted on a bench top.

C. Another common type is the pedestal grinder, which is usually larger than the bench-type and is mounted on a free-standing pedestal.



Credit: Courtesy of Instructional Materials Service, Texas A & M University

II. Parts of an utility grinder

A. Tool rest

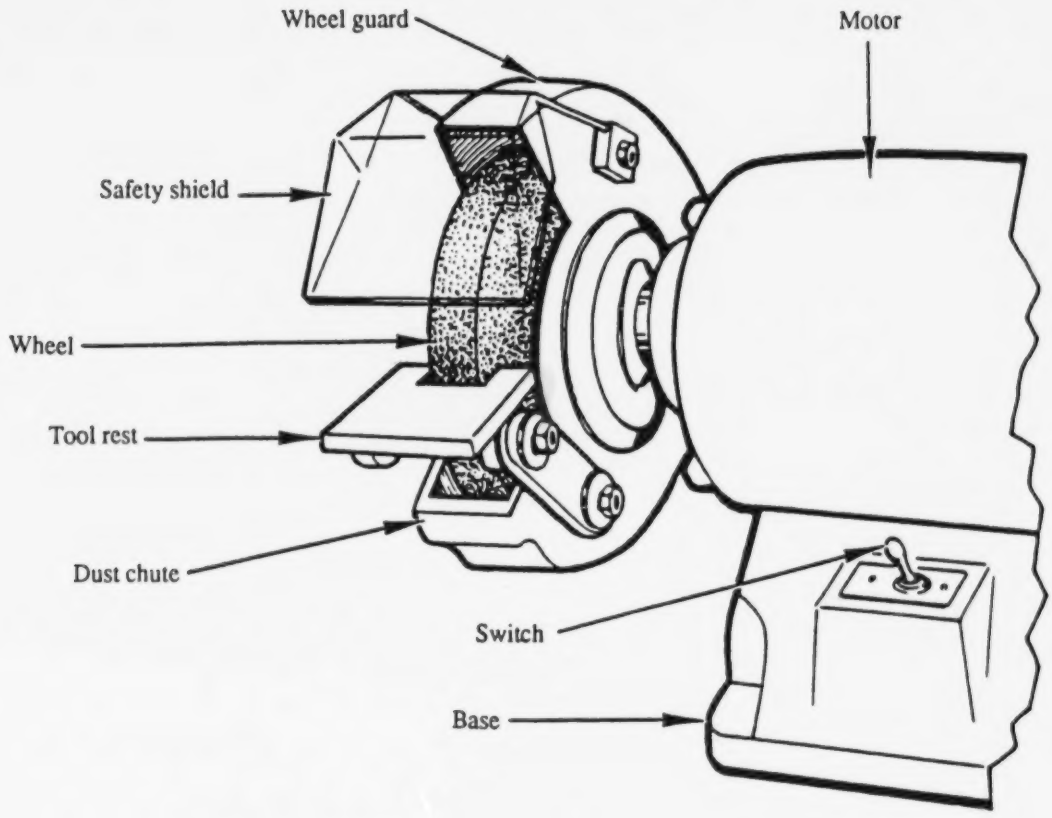
B. Water pot--used to cool parts being ground

C. Wheel guards--enclose the wheel and prevent flying pieces if the wheel breaks

D. Safety flanges--large metal washers which hold the wheel together

E. Wheel liners--paper or felt washers placed between the wheel and the safety flange to prevent damage to the wheel

F. A safety shield can be attached to the grinder. It is not a substitute for safety goggles, however!



Credit: Courtesy of Instructional Materials Service, Texas A & M University

MODULE: BENCH WORK AND MATERIAL SCIENCE

UNIT VI: PEDESTAL/BENCH GRINDER OPERATION

LESSON 3: PREPARATION FOR GRINDING

I. Changing a grinding wheel

A. Grinding wheels should be changed if they become so small in diameter that the tool rest can no longer be adjusted within a safe distance of the wheel or if the wheel becomes damaged.

B. Procedure

1. Remove wheel covers from both sides.

2. Loosen mounting nuts.

NOTE: On most grinders, one side of the motor has right-hand threads and the other has left-hand threads. This permits the nuts to be loosened and tightened by placing a wrench on either end of the motor shaft.

3. Slide off the wheel to be replaced.

NOTE: If the wheel is damaged, it should be marked as such and then thrown away so that it can't be reinstalled later.

4. Since a cracked wheel can come apart, grinding wheels should be checked for cracks before installation.

a. Inspect the wheel visually and check by "ringing."

b. Suspend the wheel by the arbor hole and then tap lightly with a soft mallet or tool handle.

c. A good wheel will ring clearly when struck. If in doubt, see the instructor.

5. With wheel liners in place, put the new wheel on the arbor.

6. Tighten nuts until they are snug.

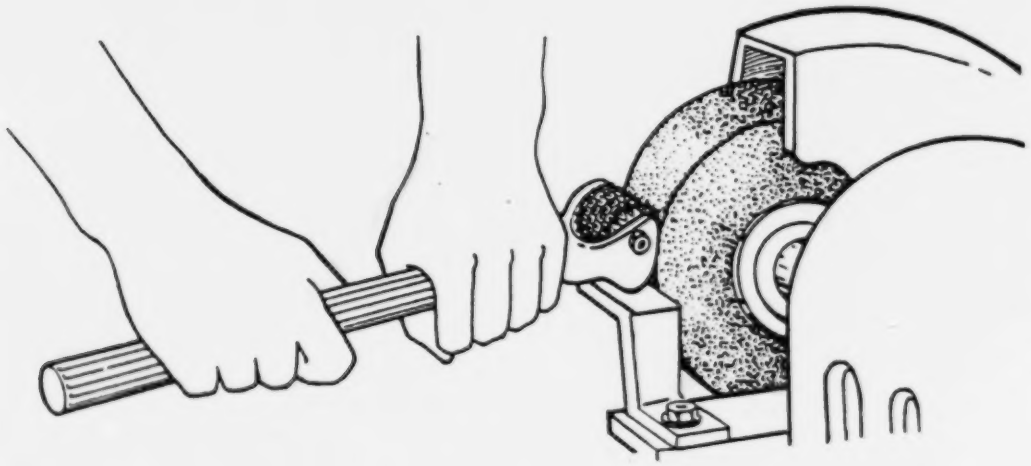
CAUTION: Do not tighten too much.

II. Reasons for dressing and truing a grinding wheel (sharpening and shaping the wheel face)

A. The wheel surface is glazed over or loaded and will no longer cut.

B. The wheel has worn unevenly and the face is no longer square.

C. A new wheel must be dressed so that it will run concentrically and be in proper balance.



Credit: Courtesy of Instructional Materials Service, Texas A & M University

III. Safety considerations

A. Adjust the tool rest to within 1/16" of the face of the wheel. This will prevent most objects from being drawn into the space between the tool rest and the wheel.

B. Wear full goggles plus safety glasses with side shields when operating a grinder. Considerable dust and particles are generated by grinding, so ordinary safety glasses are inadequate.

C. Ring test all wheels before installation.

D. Stand to the side of the grinder when starting it. Most wheel breakage occurs while the wheel is reaching its final speed.

E. Never wear gloves when operating a grinder. Secure loose clothing and long hair.

DRESS AND TRUE GRINDING WHEELS ON PEDESTAL/BENCH GRINDER

Equipment:

Utility grinder (pedestal or bench type)
Two grinding wheels (coarse and fine)
Two adjustable wrenches
Flat or cross-head screwdriver (depends on the screw type on wheel covers)
Safety glasses and goggles
Small rubber or plastic-head mallet
Star wheel dresser

CAUTION: To prevent starting the grinder accidentally while adjustments are being made, always disconnect the power from the machine first.

CAUTION: Safety glasses must be worn.

Procedure:	Evaluation 3	2	1	N
1. To test and install the grinding wheels, remove covers from both grinding wheels after disconnecting power.	—	—	—	—
2. Loosen the mounting nuts on the wheel arbors by placing an adjustable wrench on each nut. (Remember that one of the threads is likely to be left-handed.) Remove nuts and wheel flanges.	—	—	—	—
3. Slide wheels off the arbor. Be sure to save any arbor sleeves and the paper washers. Suspend one wheel by its arbor hole and test by tapping lightly around its circumference with the mallet. It should ring freely. Discard if it does not. Repeat with the other wheel.	—	—	—	—
4. Replace wheels, paper washers, flanges and nuts exactly as they were removed. Tighten nuts snugly. Do not over-tighten!	—	—	—	—
5. Replace wheel covers. Turn wheels by hand to make sure that they turn freely with no interference from the tool rest or other parts.	—	—	—	—
6. To dress grinding wheels, put on safety goggles and stand to one side of the grinder. Reconnect and turn on power. Allow the grinder to reach full speed and run for a few seconds.	—	—	—	—
7. Stand in front of the grinder with feet spread at a comfortable distance. Grasp the star dresser in one hand while the other hand firmly holds the dresser on the work rest. Press the dresser firmly against the revolving grinding wheel.	—	—	—	—
8. Slowly move the dresser from side to side across the face of the wheel. Be careful not to run off the edge. Hold the dresser firmly against the wheel at all times. Continue until the wheel is square and true.	—	—	—	—
9. Turn off the power. Adjust the tool rest to within 1/16" (1.5 mm) of the wheel face.	—	—	—	—
10. Repeat steps 6-9 with the other wheel.	—	—	—	—

Average of above evaluations* _____

*This average is the student's final evaluation for competency E9: Dress and true grinding wheels on pedestal/bench grinder.

MODULE: BENCH WORK AND MATERIAL SCIENCE

UNIT VI: PEDESTAL/BENCH GRINDER OPERATION

LESSON 4: SHARPENING A COLD CHISEL

I. Hand tools that can be sharpened on a utility grinder

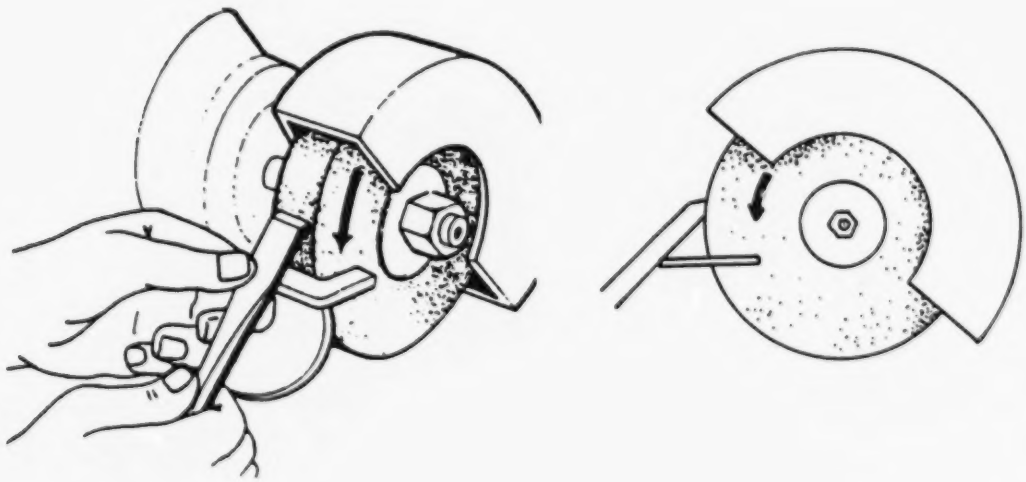
- A. Drills
- B. Chisels
- C. Screwdriver blades

II. Burning the temper--allowing the tool to become so hot while grinding that the metallurgical properties (especially hardness) are altered.

- A. The part will turn brown or blue when this occurs.
- B. The tool may be ruined.
- C. Use the water pot often to prevent this burning.

III. Sharpening a cold chisel

- A. Attempt to make the chisel end square with its length.
- B. The included cutting angle should be 60°.
- C. Hold the chisel in both hands with the shank resting on the tool rest.
- D. Inspect the angle with a center gage.



SHARPEN A COLD CHISEL

Equipment:

Utility grinder (pedestal or bench type)
Flat cold chisel
Safety goggles
Center gage or protractor head and blade from a combination set

CAUTION: Safety goggles must be worn when operating an utility grinder.

Procedure:	Evaluation 3	2	1	N
1. Dress grinding wheel as needed. Adjust tool rest to within 1/16" of the wheel face.	—	—	—	—
2. Place the blade end of the cold chisel on the tool rest of the grinder. Place the cutting end of the chisel lightly against the wheel face at approximately the center of the grinder shaft. Move the chisel back and forth across the face. Continue until the end is square with the shank and all nicks and dents have been removed.	—	—	—	—
NOTE: If the chisel point becomes overheated, the chisel can be ruined. Dip the chisel in the water pot frequently.				
3. The included angle of the chisel point should be 60°. Tilt the chisel point up to create one side of the angle. Turn the chisel over to shape the other side. Using light pressure against the wheel, move the tool back and forth across the wheel face.	—	—	—	—
4. Using a center gage or protractor, check the angle of the chisel point frequently during grinding. Adjust the procedure as necessary.	—	—	—	—
Average of above evaluations*	—	—	—	—

*This average is one-half the student's evaluation for competency E10: Grind and shape tools on pedestal/bench grinder.

MODULE: BENCH WORK AND MATERIAL SCIENCE

UNIT VI: PEDESTAL/BENCH GRINDER OPERATION

LESSON 5: GRINDING A LATHE TOOLBIT

I. General description

A. The lathe toolbit is a basic lathe cutting tool ground from a square toolbit blank of high-speed steel.

B. Specific angles are ground to produce a cutting edge.

C. Toolbit grinding is an essential skill for all machinists.

D. Toolbit geometry **(HO 5.1)**

1. Surfaces for a general-purpose, right-hand cutting tool

a. Side cutting and side relief

b. End cutting/nose radius and end relief

c. Side rake and back rake

2. Specifications for cutting, rake and relief angles

a. Side cutting-edge angle: 20°

b. Side relief angle: 8-10°

c. End cutting-edge angle: 30°

d. Nose radius: 1/32" or less

e. End relief angle: 8-10°

f. Side rake angle: 8-10°

g. Back rake angle: 8-10°

II. Procedure for grinding a lathe toolbit **(TM 5.1)**

CAUTION: While operating a pedestal grinder, wear safety glasses and do not wear gloves.

A. The grinding wheel must be true and sharp.

1. Dress as necessary.

2. Adjust tool rest to within 1/16" of the wheel.

B. Grasp the toolbit firmly and support hands on the tool rest.

C. Steps for grinding toolbit angle

NOTE: Usually, two angles must be ground simultaneously.

1. Grind the cutting-edge and side relief angles. Continue until the cutting edge is about 1/2" (13 mm) long and the point is more than one-fourth the width of the toolbit.

   NOTE: While grinding, move the toolbit slowly across the face of the wheel. This will prevent grooves in the face of the wheel.

2. Be careful not to overheat the tool blank. Cool frequently by dipping in the water pot.

3. Grind the end cutting-edge angle so that it forms an angle of less than 90° with the side cutting-edge angle. At the same time, form the end relief angle.

4. Round the point slightly to form the nose radius. Maintain the same end and side relief angles.

5. Grind the side rake angle on top of the toolbit.

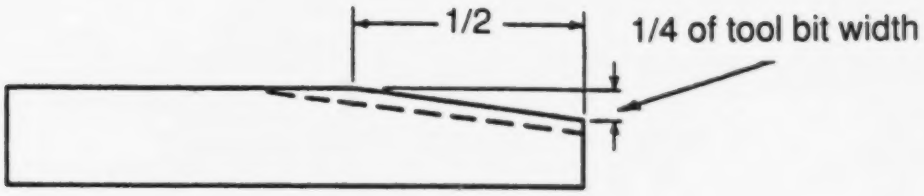
6. Apply a few drops of light oil to the face of an oilstone. Lightly hone the cutting-edge angle and nose radius on the oilstone.

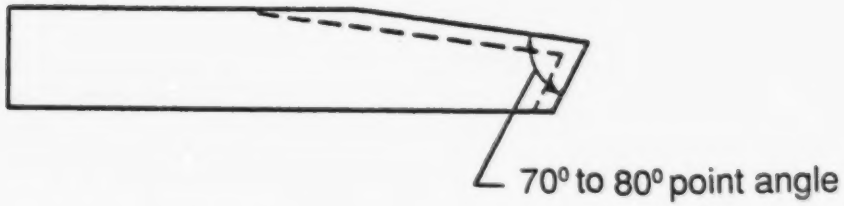
D. Measuring toolbit geometry

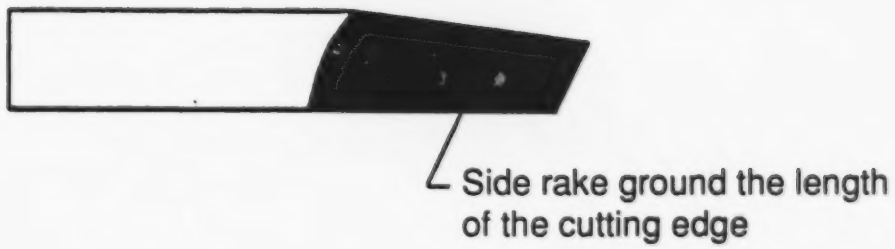
1. Measure cutting-edge angles with a protractor.

2. Measure end and side relief angles with a toolbit gage. The toolbit must be mounted in a toolholder.

STEPS IN TOOLBIT GRINDING

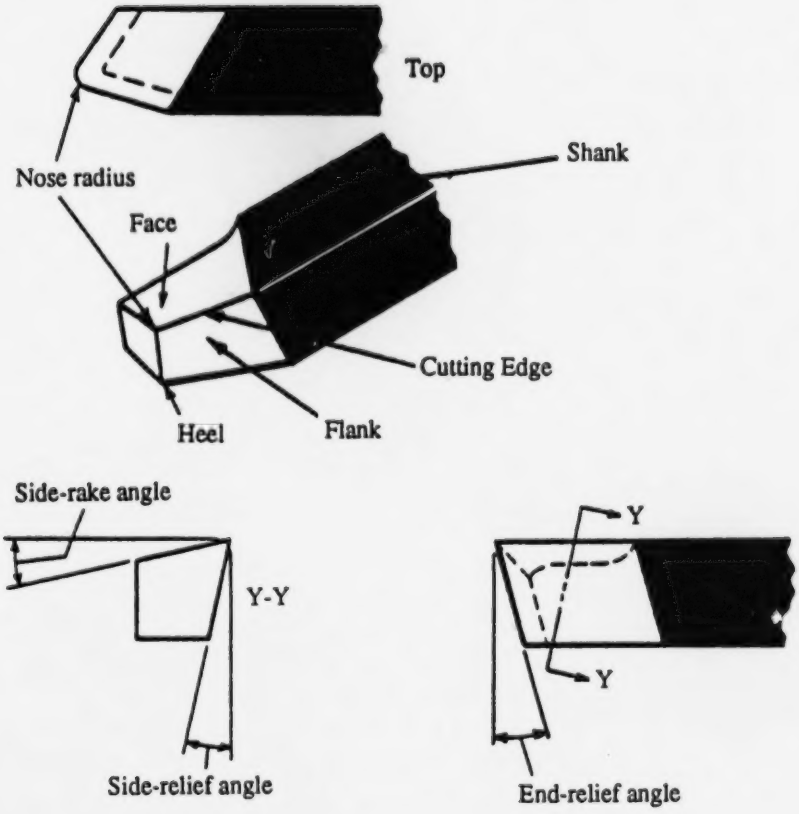






Credit: Krar, S. F. and J. W. Oswald. Turning Technology. Albany, NY: Delmar, © 1971, pg. 45. Reproduced by permission.

LATHE TOOLBIT GEOMETRY



Credit: Krar, S. F. and J. W. Oswald. Turning Technology. Albany, NY: Delmar, © 1971, pg. 37. Reproduced by permission.

GRIND A LATHE TOOLBIT

Equipment:

Utility grinder (pedestal or bench type)
Safety goggles
Protractor head and blade of combination set
Toolbit gage
1/4", 5/16" or 3/8" high-speed steel toolbit blank
Lathe toolholder
Light oil
Fine oilstone

CAUTION: Safety goggles must be worn while operating an utility grinder.

Procedure:	Evaluation 3	2	1	N
1. Dress the grinding wheel as necessary. Adjust the tool rest to within 1/16" of the face of the wheel.	—	—	—	—
2. Grasp the toolbit while resting hands on the tool rest.	—	—	—	—
3. While tilting the toolbit, grind the cutting-edge angle to form a 10° side relief angle.	—	—	—	—
NOTE: Move the toolbit back and forth across the face of the wheel. Dip the toolbit in the water pot occasionally to keep it cool.				
4. Grind the end cutting edge so that it creates an angle of less than 90° with the side cutting edge. Form the 15° end relief angle at the same time by lowering the back end of the toolbit.	—	—	—	—
5. Grind the side rake on top of the toolbit.	—	—	—	—
6. Create the nose radius by rounding the point created by the end cutting-edge angle and side cutting-edge angle.	—	—	—	—
7. Place a few drops of oil on the oilstone. Hone the cutting edge and nose radius with the oilstone to produce a finer edge.	—	—	—	—
Average of above evaluations*	—	—	—	—

*This average completes the student's evaluation for competency E10: Grind and shape tools on pedestal/bench grinder.

MODULE: BENCH WORK AND MATERIAL SCIENCE

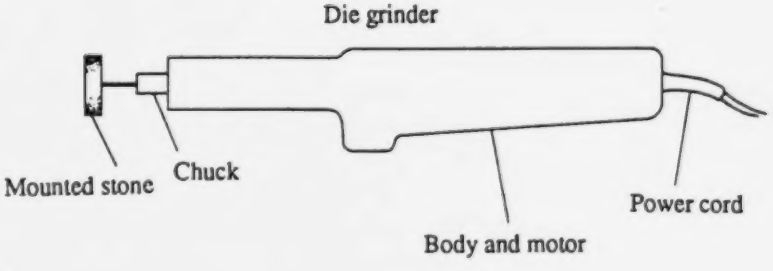
UNIT VI: USING A HAND GRINDER

LESSON 6: HAND GRINDERS

I. Description of precision grinders

A. Parts and construction

1. Body
2. Chuck
3. Chuck wrench



4. Cutting tools **(TM 6.1)**
   a. Abrasive wheels and mounted stones
   b. Burrs
   c. Rotary files

B. Drive systems

1. Pneumatic grinders
   a. Driven by compressed air
   b. Light grinding at extremely high speeds (15,000-80,000 rpm)
2. Electric die grinders
   a. Driven by high-torque and high-speed electric motors
   b. For heavier grinding operations

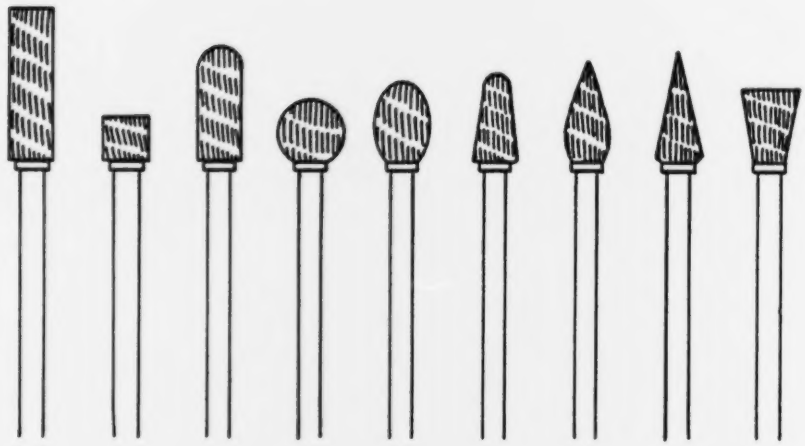
II. Applications

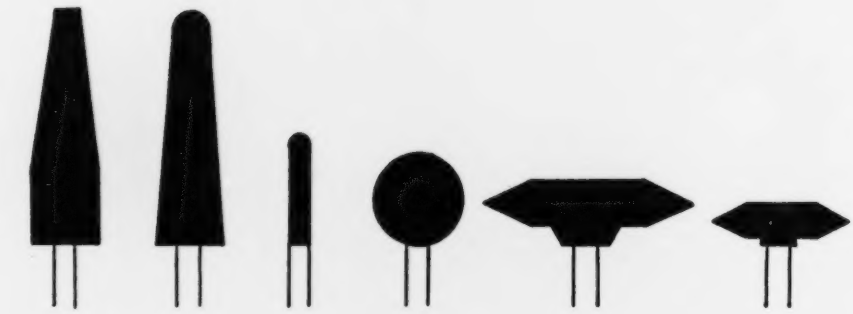
A. Create part geometry which is too complex for conventional machining

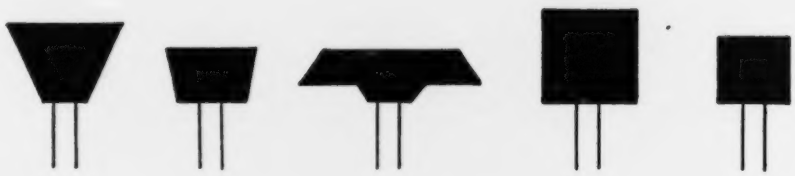
B. Shape material which is inaccessible except by hand methods

C. Perform deburring

TOOLING FOR PRECISION DIE GRINDERS







GRIND USING APPROPRIATE HAND GRINDER

Equipment:

Electric or air die grinder
Chuck wrench or key
1/4" diameter mounted stone
Radius gauge set
Workpiece, cold-rolled mild steel, 1" x 1" x 6"
Bench vise
Layout blue

NOTE: The expected outcome is a 5/16" radius on one long corner of the workpiece. The radius will be checked with radius gages.

CAUTION: Approved goggles must be worn at all times when operating a grinder since grinding operations tend to produce hot sparks and particles.

Procedure:		Evaluation 3	2	1	N
1.	Install the mounted stone in the chuck of the grinder.	—	—	—	—
2.	Secure workpiece in the vise.	—	—	—	—
3.	Apply layout blue to the surface adjacent to the corner. Layout blue is used to make certain that the grinder does not slip onto the surfaces adjacent to the corner being shaped.	—	—	—	—
4.	Begin grinding the corner. Use a long sweeping motion along the entire corner. Do not stop or hold the grinder on one spot as this will cause the grinder to dig in and remove too much material.	—	—	—	—
5.	Inspect the radius with radius gages until the desired profile is achieved. The radius must be of the proper dimensions and uniform along the entire length.	—	—	—	—
6.	Check to see that there are no marks in the layout blue, which indicates that the grinder has not touched that area.	—	—	—	—
Average of above evaluations*		—	—	—	—

*This average is the student's final evaluation for competency E12: Grind using appropriate hand grinder.

MODULE: BENCH WORK AND MATERIAL SCIENCE

UNIT VI: PEDESTAL/BENCH GRINDER OPERATION

UNIT TEST

Select the option which best answers the question or completes the statement.

___ 1. Which of the following is <u>not</u> a good reason for using grinding operations?

a. Removes material at a high rate
b. Sharpens cutting tools
c. Cuts very hard materials economically
d. Produces a fine surface finish
e. All of the above

___ 2. What do grinding wheels consist of?

a. Metallic particles embedded in aluminum oxide
b. Plastic resins and sharp metallic particles
c. A combination of paper and abrasive grains
d. Abrasive grains and bonding material
e. None of the above

___ 3. How are the particles used in grinding wheels specified?

a. Screen size and material type
b. Average particle diameter
c. Particle diameter and material type
d. Number of sharp edges
e. None of the above

___ 4. Which type of material is <u>not</u> used to hold abrasive particles together?

a. Paper or compressed wood products
b. Clay
c. Silicate (sand)
d. Resin
e. Rubber

___ 5. What specifications are needed when ordering a grinding wheel?

a. Wheel diameter and shape
b. Wheel width and arbor hole diameter
c. Arbor hole and wheel diameter
d. Operating speed and wheel diameter
e. All of the above

____ 6. What do grade designations for grinding wheels refer to?

a. Grain size
b. Hole diameter
c. Structure
d. Hardness
e. None of the above

Identify the parts of the utility grinder shown below.

____ 7. Base

____ 8. Dust chute

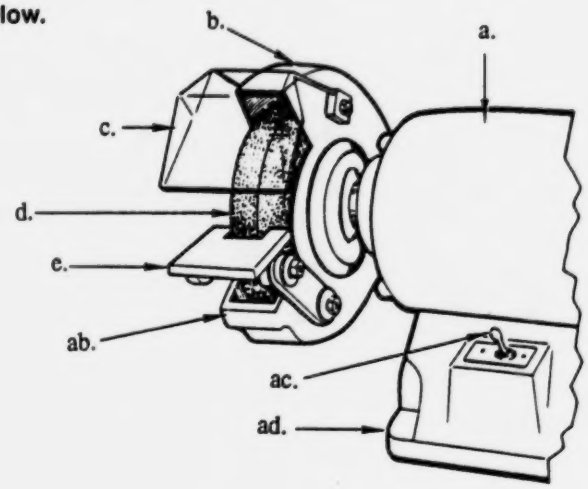
____ 9. Safety shield

____ 10. Switch

____ 11. Tool rest

____ 12. Wheel

____ 13. Wheel guard



Credit: Courtesy of Instructional Materials Service, Texas A & M University

Select the option which best answers the question or completes the statement.

____ 14. Which is <u>not</u> a reason for dressing a grinding wheel?

a. To remove glazing or loaded surface from face
b. To correct uneven wear due to use
c. To repair a damaged or broken wheel
d. To balance a new wheel
e. All of the above

____ 15. The tool rest on an utility grinder is adjusted to within what distance of the wheel face?

a. 1/4"
b. 1/16"
c. 1/2"
d. 1/64"
e. 3/8"

____ 16. Which statement about a damaged grinding wheel is false?

a. Damage can be detected by "ringing."
b. It can be repaired or redressed by the manufacturer.
c. It can fly apart if used.
d. It should be clearly marked as damaged.
e. None of the above

___ 17. Which practice is inappropriate when using an utility grinder?

a. Wearing gloves to protect the hands
b. Ringing grinding wheels before installation
c. Wearing safety goggles
d. Making proper tool rest adjustment
e. Quenching workpiece regularly to keep cool

___ 18. Which describes a tool which has been turned blue by grinding?

a. Properly sharpened
b. Has been burned and may be ruined
c. Should be polished and honed
d. Has been kept too cool during grinding
e. None of the above

___ 19. Which is a specification for an end cutting-edge angle?

a. 8-10°
b. 15°
c. 20°
d. 30°
e. 45°

___ 20. How are angles on a lathe toolbit measured?

a. Ruler
b. Center gage
c. Toolbit gage and protractor
d. Micrometer
e. None of the above

___ 21. Which of the following is an application for a hand-held grinder?

a. Create complex part geometry
b. Remove material in inaccessible areas
c. Deburring
d. All of the above
e. None of the above

___ 22. Which hand tool would not be sharpened on a utility grinder?

a. Drill
b. Chisel
c. Screwdriver blade
d. Hammer head
e. All of the above

For items 23-27, indicate "a" if the item applies to electric grinders and "b" if it applies to pneumatic hand-held grinders.

____ 23. High torque

____ 24. Extremely high speeds

____ 25. Light grinding only

____ 26. Requires compressed air for operation

____ 27. Heavy-duty grinding applications

____ 28. List the two types of utility grinders discussed in this unit.

a.

b.

ANSWERS TO UNIT TEST

1.	a	(E10)	15.	b	(E10)
2.	d	(E10)	16.	b	(E10)
3.	a	(E10)	17.	a	(E10)
4.	a	(E10)	18.	b	(E10)
5.	e	(E10)	19.	d	(E10)
6.	d	(E10)	20.	c	(E10)
7.	ad	(E9, E10)	21.	d	(E12)
8.	ab	(E9, E10)	22.	d	(E12)
9.	c	(E9, E10)	23.	a	(E12)
10.	ac	(E9, E10)	24.	b	(E12)
11.	e	(E9, E10)	25.	b	(E12)
12.	d	(E9, E10)	26.	b	(E12)
13.	b	(E9, E10)	27.	a	(E12)
14.	c	(E9)	28.	Bench, pedestal	(E9, 10)

MODULE: BENCH WORK AND MATERIAL SCIENCE

UNIT VII: WHETTING, POLISHING AND LAPPING

UNIT OBJECTIVE

Upon completion of this unit, the student should be able to describe and perform operations involving abrasive materials, including whetting (honing), lapping and polishing. This knowledge will be evidenced by achieving a specified score on job sheets and the unit test.

SPECIFIC OBJECTIVES

After completion of the lessons in this unit, the student should be able to:

1.1 Identify the purposes and equipment needed for honing.

1.2 Hone a lathe tool. (competency E11, JS 1.1)

2.1 Identify the purposes of buffing.

2.2 Identify the equipment needed for buffing.

2.3 Buff a workpiece. (competency E11, JS 2.1)

3.1 Identify the purposes of lapping.

3.2 Identify the equipment and materials needed for lapping.

3.3 Identify the factors affecting the quality of the finish.

3.4 Lap a workpiece. (competency E11, JS 3.1)

MODULE: BENCH WORK AND MATERIAL SCIENCE

UNIT VII: WHETTING, POLISHING AND LAPPING

CONTENTS OF THIS UNIT

A. Objective sheet

B. References

C. Notes to the instructor

D. Lesson plans

1. Lesson 1: HONING A LATHE TOOLBIT

   a. Information outline

   b. Job sheet

      JS 1.1: Hone a lathe tool

2. Lesson 2: BUFFING METAL SURFACES

   a. Information outline

   b. Job sheet

      JS 2.1: Buff a workpiece

3. Lesson 3: HAND LAPPING

   a. Information outline

   b. Transparency master

      TM 3.1: Surface finish gage

   b. Job sheet

      JS 3.1: Lap a workpiece

E. Unit test

F. Answers to unit test

REFERENCES

A. Books

1. Repp, Victor E., and Willard J. McCarthy. Machine Tool Technology. 5th ed. Bloomington, IL: McKnight Publishing Co., 1984.

2. Repp, Victor E., Willard J. McCarthy and Oswald A. Ludwig. Metalwork Technology and Practice. Bloomington, IL: McKnight Publishing Co., 1982.

B. Curriculum guide

1. Benson, Robert T., and Margaret R. Gregory. V-TECS Guide for Machine Shop. Columbia, SC: South Carolina Department of Education, 1985.

C. Other references

1. Brown, L. "Practical Lapping." Final Finish Technology. Winter 1988: 20-25.

MODULE: BENCH WORK AND MATERIAL SCIENCE

UNIT VII: WHETTING, POLISHING AND LAPPING

LESSON 1: HONING A LATHE TOOLBIT

I. Honing purposes and equipment

A. Provides a keener edge on a newly ground tool

B. Touch-up on a tool before taking a finish cut

C. Equipment needed

1. Whetstone (abrasive block)

a. Natural or synthetic abrasive

b. Hardness from hard to soft

2. Light oil such as a sewing machine oil

NOTE: Using oil on the whetstone keeps metal particles from becoming embedded in the stone.

II. Procedure

A. Use a medium-soft, natural stone for best results.

B. Apply 2-3 drops of oil to one side of the stone.

C. Hold the stone against the edge of the tool to be honed and move it up and down until the entire cutting edge has been honed.

NOTE: Be careful to avoid changing the relief angles produced by grinding. This can make the tool useless.

D. After the cutting edge and nose radius have been finished, stone the top of the tool lightly.

E. Wipe the tool clean with a rag.

HONE A LATHE TOOL

Equipment:

Medium-soft, natural whetstone
Light oil
Lathe toolbit

Procedure:	Evaluation 3	2	1	N
1. Apply 2-3 drops of oil to one side of the stone.	—	—	—	—
2. Hold the stone against the edge of the tool to be honed and move it up and down until the entire cutting edge has been honed.	—	—	—	—
NOTE: Be careful to avoid changing the relief angles produced by grinding. This can make the tool useless.				
3. After the cutting edge and nose radius have been finished, stone the top of the tool lightly.	—	—	—	—
4. Wipe the tool clean with a rag.	—	—	—	—
5. As directed by instructor, prepare for next job sheet or clean up area and return tools and materials.	—	—	—	—
Average of above evaluations*	—	—	—	—

*This average is the student's partial evaluation for competency E11: Use abrasives/whetting/polishing/lapping.

MODULE: BENCH WORK AND MATERIAL SCIENCE

UNIT VII: WHETTING, POLISHING AND LAPPING

LESSON 2: BUFFING METAL SURFACES

I. Purposes of buffing

A. Polish a metal surface

B. Prepare a surface for electroplating or other surface finish

II. Equipment for buffing

A. Buffing machine

1. Utility grinder with buffing wheel mounted

2. Buffing head

B. Buffing wheels

1. Cloth

2. Leather

3. Felt

4. Wire wheel

NOTE: A wire wheel can be used to produce a satin finish on some metals such as aluminum. It is also used to deburr and remove rust and corrosion. It does not require any buffing compounds.

C. Buffing compound constituents

1. Very fine abrasive material

a. Lime

b. Tripoli ("rotten stone")

c. Crocus (an iron oxide compound)

d. Rouge (an iron oxide compound)

e. Emery

f. Aluminum oxide

2. Carrier material

a. Tallow or heavy grease

b. Waxes and paraffins

III. Procedure for buffing

A. Safety

1. Safety goggles must be worn when buffing.

2. During large buffing jobs, it is advisable to wear some form of dust mask or respirator for protection from dust.

3. Do not wear gloves while buffing. Roll up long sleeves above the elbow. Remove rings, watches and jewelry.

B. Select wheel and compound.

C. If using the wheel on an utility grinder, remove the tool rest.

D. Apply the compound to the revolving wheel by holding a block against the wheel.

E. Stand comfortably with feet spread slightly apart to assure balance.

F. Hold workpiece firmly, then hold it against the wheel. Apply pressure at the center of the wheel or below.

CAUTION: Do not point any part of the workpiece directly into the wheel. If the wheel grabs the part, it could be jerked violently from your hands, causing injury.

G. Check the workpiece surface frequently and continue until the desired finish is achieved.

H. Clean the workpiece with solvent to remove any abrasive and grease carrier.

BUFF A WORKPIECE

Equipment:

Buffing head or utility grinder
Cloth buffing wheel
Rouge buffing compound
6" x 6" aluminum plate workpiece
Safety goggles

CAUTION: Safety goggles must be worn when buffing. Also, it is advisable to wear some form of dust mask or respirator to prevent breathing the dust produced by large buffing jobs. Do not wear gloves while buffing. Roll up long sleeves above the elbow. Remove rings, watches and jewelry.

Procedure:	Evaluation 3	2	1	N
1. Remove the tool rest if using the wheel on an utility grinder.	—	—	—	—
2. Apply the compound to the revolving wheel by holding a block against the wheel.	—	—	—	—
3. Stand comfortably with feet spread slightly apart to assure balance. Hold the workpiece firmly and hold it against the wheel. Apply pressure at the center of the wheel or below to the face of the workpiece. Check the workpiece frequently and continue until the desired finish is achieved.	—	—	—	—
CAUTION: Do not point any part of the workpiece directly into the wheel. If the wheel grabs the part, it could be jerked violently from your hands, causing injury.				
4. Clean the workpiece with solvent to remove any abrasive and grease carrier.	—	—	—	—
5. Replace the tool rest if required.	—	—	—	—
6. As directed by instructor, prepare for next job sheet or clean up area and return tools and materials.	—	—	—	—
Average of above evaluations*	—	—	—	—

*This average is the student's partial evaluation for competency E11: Use abrasives/whetting/polishing/lapping.

MODULE: BENCH WORK AND MATERIAL SCIENCE

UNIT VII: WHETTING, POLISHING AND LAPPING

LESSON 3: HAND LAPPING

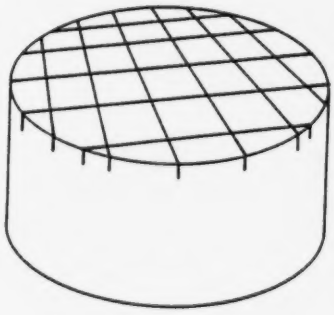
I. Purposes of lapping

A. Obtain greater accuracy of dimensions

B. Obtain a smoother surface

C. Improve the fit between parts

II. Equipment and materials for lapping



A. Laps--flat block of soft, fine-grained cast iron. The surface is scored with narrow grooves about 1/2" apart for a checker-board effect.

B. Abrasive compounds

1. Aluminum oxide
2. Silicon carbide
3. Diamond
4. Garnet
5. Rouge

NOTE: Lapping compounds are available as a powder or mixed with a grease or oil vehicle.

C. Lubricant/light oil

III. Factors affecting the quality of the surface finish

A. Abrasive grit size

B. Part material

C. Part hardness

IV. General guidelines and procedure

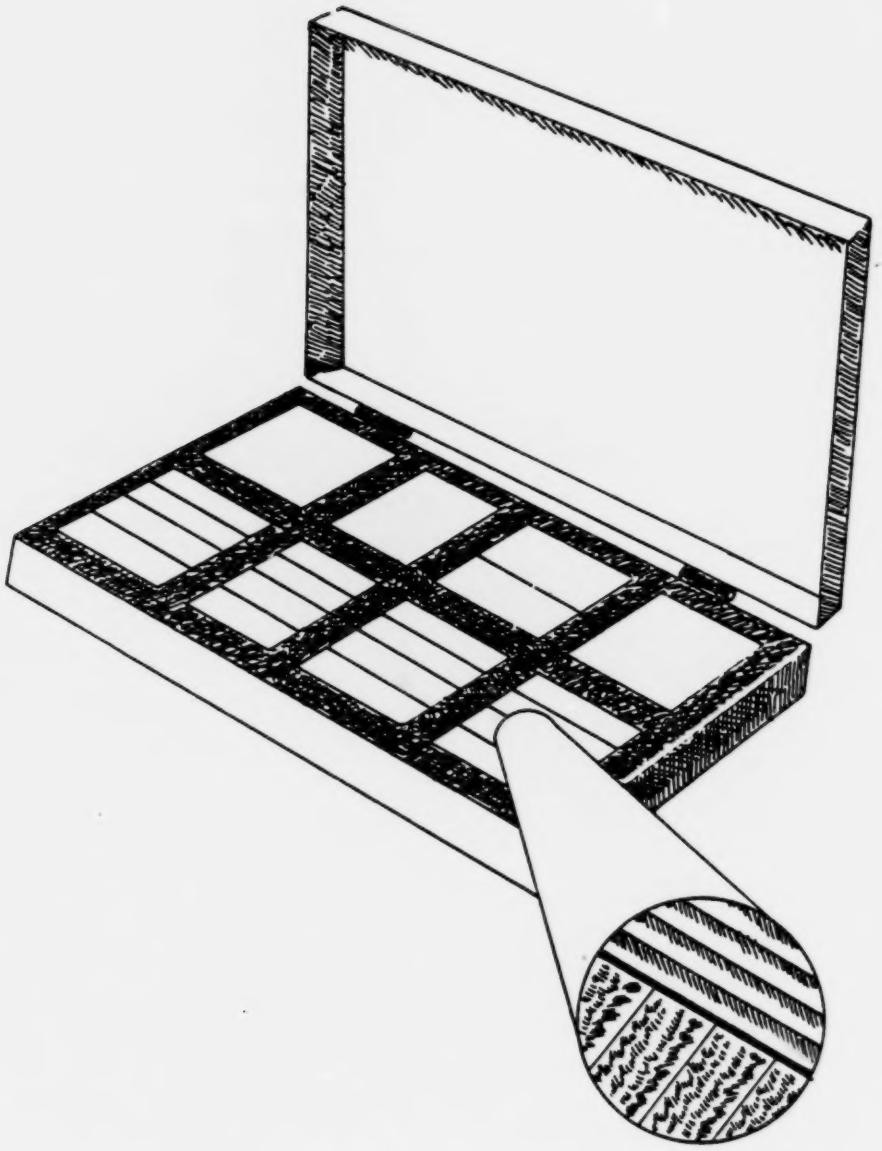
A. Guidelines

1. The lap should be softer than the part to be lapped.
2. The abrasive should be as hard as the part.
3. Use lapping compound sparingly.
4. Lapping compounds are sized by microns. (One micron = one millionth of an inch).

B. Procedure **(TM 3.1)**

1. Clean and deburr the workpiece.
2. Select the appropriate lapping powder.
    a. Soft metals require a soft abrasive such as garnet or red rouge.
    b. Aluminum oxide can be used on harder materials such as steel.
    c. Diamond compounds should be used for tungsten carbide or hardened steel.
3. Apply a small amount of compound and lubricant to lap.
4. Lap the metal surface.
    a. Use a figure-eight motion.
    b. Cover the entire surface.
    c. Apply even pressure.
5. Check the lapped surface against specifications and surface finish gage.

SURFACE FINISH GAGE



LAP A WORKPIECE

Equipment:

Aluminum oxide or silicon carbide lapping powder
Light oil
Cast iron lap
Workpiece

Procedure:	Evaluation 3	2	1	N
1. Clean and deburr the workpiece.	—	—	—	—
2. Apply a small amount of compound and lubricant evenly to the lap.	—	—	—	—
3. Turn surface to be lapped face down on the lap.	—	—	—	—
4. Apply light, even pressure and begin lapping with a figure-eight motion. Be sure to lap the entire surface of the part.	—	—	—	—
5. Check the lapped surface against specifications and the surface finish gage.	—	—	—	—
6. Wipe the lapped surface clean with soft, clean cloth.	—	—	—	—
Average of above evaluations*	—	—	—	—

*This average completes the student's evaluation for competency E11: Use abrasives/whetting/polishing/lapping.

MODULE: BENCH WORK AND MATERIAL SCIENCE

UNIT VII: WHETTING, POLISHING AND LAPPING

UNIT TEST

Select the option which best answers the question or completes the statement.

___ 1. Why is it important to be careful when honing a lathe tool?

a. The tool can become embedded in the hone.
b. Relief angles can be changed by excessive honing.
c. Lubricant can discolor the workpiece.
d. The tool will be reground after honing.
e. None of the above

___ 2. Which type of stone is recommended for honing?

a. Natural stone of medium-soft hardness
b. Synthetic extra-hard
c. Resin bond soft
d. Natural hard
e. None of the above

___ 3. Why must a lubricant be used when honing?

a. Prevent particles from becoming embedded in the stone
b. Provide a more powerful cutting action
c. Prevent the tool from slipping off the hone
d. Increase safety
e. None of the above

___ 4. Which wheel produces a satin finish on aluminum?

a. Cloth
b. Leather
c. Wire
d. Felt
e. None of the above

___ 5. What purpose does buffing serve?

a. Produces a mirror finish on a workpiece
b. Removes rust and dirt
c. Removes a large amount of material in a short time
d. Prepares a surface for welding or brazing
e. None of the above

___ 6. Which of the following is <u>not</u> a type of buffing compound?

a. Lime
b. Tripoli
c. Emery
d. Diamond
e. Aluminum oxide

___ 7. Which is a typical carrier for buffing compounds?

a. Tallow
b. Paper
c. Plastic resin
d. Vitreous bond
e. None of the above

___ 8. What might happen if a corner of a workpiece is held onto the buffing wheel?

a. The corner will be ground off.
b. The workpiece may be jerked violently from your hands, causing injury.
c. The workpiece will be buffed to a high polish.
d. A corner radius will be formed.
e. None of the above

___ 9. Which of the following is <u>not</u> a reason for lapping a workpiece?

a. Produces a mirror finish
b. Obtains greater accuracy of dimensions
c. Improves fit between parts
d. Obtains a smoother surface
e. None of the above

___ 10. Which is a common material for lapping blocks?

a. Hardened steel
b. Brass
c. Aluminum
d. Cast iron
e. None of the above

___ 11. Which material is used as a lapping abrasive?

a. Diamond
b. Aluminum oxide
c. Silicon carbide
d. Garnet
e. All of the above

___ 12. Identify three factors that affect surface finish quality when lapping.

a. Abrasive grit size, part material and part hardness
b. Lubricant weight, grit size and part hardness
c. Lap material, lubricant and part hardness
d. Lubricant, grit size and part material
e. None of the above

___ 13. In what dimension are lapping compounds sized?

a. Thousandths of an inch
b. Hundredths of a millimeter
c. Microns
d. Centimeters
e. None of the above

___ 14. What tool is used to check a lapped surface against specifications?

a. Micrometer
b. Steel rule
c. Gage block
d. Surface roughness gauge
e. None of the above

ANSWERS TO UNIT TEST (E11)

1. b
2. a
3. a
4. c
5. a
6. d
7. a
8. c
9. a
10. d
11. e
12. a
13. c
14. d

MODULE: BENCH WORK AND MATERIAL SCIENCE
UNIT VIII: SCREW, DRILL AND TAP EXTRACTION

UNIT OBJECTIVE

After completion of this unit, the student should be able to demonstrate methods for removing broken hardware and tools such as drills, taps and bolts. The student will also demonstrate installation of a helical coil insert to replace damaged threads. This knowledge will be evidenced by achieving the specified score on job sheets and the unit test.

SPECIFIC OBJECTIVES

Upon completion of the lessons in this unit, the student should be able to:

1.1 Remove a broken bolt with a ball-peen hammer and center punch. (competency E13, JS 1.1)

1.2 Remove a broken bolt with a spiral screw extractor. (competency E13, JS 1.1)

2.1 Remove a broken drill with a pin punch. (competency E14, JS 2.1)

2.2 Remove a broken tap using a tap extractor. (competency E14, JS 2.2)

2.3 Install a helical coil thread insert. (competency E16, JS 2.3)

MODULE: BENCH WORK AND MATERIAL SCIENCE

UNIT VIII: SCREW, DRILL AND TAP EXTRACTION

CONTENTS OF THIS UNIT

A. Objective sheet

B. References

C. Notes to the instructor

D. Lesson plans

1. Lesson 1: REMOVING DAMAGED SCREWS

   a. Information outline

   b. Transparency masters

      TM 1.1: Punch and hammer method
      TM 1.2: Screw extractor method

   c. Job sheets

      JS 1.1: Remove a broken screw using center punch method
      JS 1.2: Remove a broken screw using screw extractor method

2. Lesson 2: EXTRACTING BROKEN TAPS AND DRILLS

   a. Information outline

   b. Job sheets

      JS 2.1: Remove a broken drill
      JS 2.2: Remove a broken tap
      JS 2.3: Install a helical coil thread insert

E. Unit test

F. Answers to unit test

REFERENCES

A. Book

1. Repp, Victor E., Willard J. McCarthy and Oswald A. Ludwig. Metalwork Technology and Practice. Bloomington, IL: McKnight Publishing Co., 1982.

B. Curriculum guide

1. Benson, Robert T., and Margaret R. Gregory. V-TECS Guide for Machine Shop. Columbia, SC: South Carolina Department of Education, 1985.

NOTES TO THE INSTRUCTOR

A. Suggested approaches to teaching this unit

1. This unit's job sheets require workpieces which contain broken components (i.e. drills, screws and taps). Sample workpieces for Lesson 1 can be prepared by tapping a block of aluminum or steel and then breaking off screws in the tapped holes. Of course, safety eye wear should be worn when preparing these workpieces.

2. It may not be desirable--or even safe--to actually break taps and drills so students can test their competence in removing broken taps and drills. As alternative to the job sheets, questions #13 and 14 on the unit test have been provided as alternative means of measuring competency E14.

MODULE: BENCH WORK AND MATERIAL SCIENCE

UNIT VIII: SCREW, DRILL AND TAP EXTRACTION

LESSON 1: REMOVING DAMAGED SCREWS

I. Punch and hammer method for broken screw removal **(TM 1.1)**

A. This procedure involves using a center punch to turn the broken bolt out of the hole until enough of it protrudes to be grasped and removed with pliers.

B. Equipment needed

1. Center punch
2. 10 or 12 oz. ball-peen hammer
3. Locking pliers
4. Tap matching designation of bolt being removed and tap handle or wrench.

C. Procedure

CAUTION: Safety goggles must be worn when using center punches, hammers other striking tools.

1. Determine if screw is left- or right-handed.
2. Turn punch at 45° to center axis of bolt so that the punch point will engage the top of the broken bolt.
3. Strike punch with hammer and attempt to force bolt to back out of the hole.
4. Continue until a portion of the bolt is above the surface of the workpiece.
5. Lock pliers onto bolt and turn until the bolt is completely removed from the hole.
6. After choosing an appropriate tap and tap handle, carefully run the tap back into the hole to remove any debris and re-shape slightly damaged threads.

   NOTE: If the threads are stripped or extensively damaged, it may be necessary to enlarge the hole and use a bigger bolt in the application or install a helical coil thread insert.

II. Screw extractor method **(TM 1.2)**

NOTE: Safety glasses must be worn when working with screw extractors.

A. This procedure involves drilling a hole into the broken bolt and then forcing a screw extractor into the hole. The drive end of the extractor fits into a tap handle and can be turned to removed the broken bolt.

B. Equipment needed

1. Common screw extractor and drill set

   a. #1 screw extractor--5/64 drill

b. #2 screw extractor--7/64 drill

c. #3 screw extractor--5/64 drill

d. #4 screw extractor--1/4 drill

e. #5 screw extractor--17/64 drill

2. Tap handle

3. 10 or 12 oz. ball-peen hammer

4. 3/8" or 1/2" electric hand drill or drill press

5. Center punch

6. Center drill, #2 or #3

B. Procedure

NOTE: Standard screw extractors will work only with right-hand threads.

1. Secure workpiece in vise.

2. Center punch damaged screw.

   NOTE: This must be done carefully as the center punch mark guides the drills which follow. If the mark is off-center, the drills may damage the workpiece or make it impossible to use the screw extractor effectively.

3. Select screw extractor; it should be small enough to fit inside the minor diameter of the screw about half-way up the flutes of the extractor.

4. Drill damaged screw with center drill and then with a twist drill appropriate for the extractor being used. (See equipment needed list above.)

   NOTE: Obtain permission from the instructor before operating the drill press or portable electric hand drill.

   CAUTION: Drilling the workpiece can create burrs. Be sure to remove any burrs before continuing to work.

5. Insert extractor into drilled hole. It may be necessary to tap the screw extractor lightly with a rubber-faced mallet to seat it in the hole.

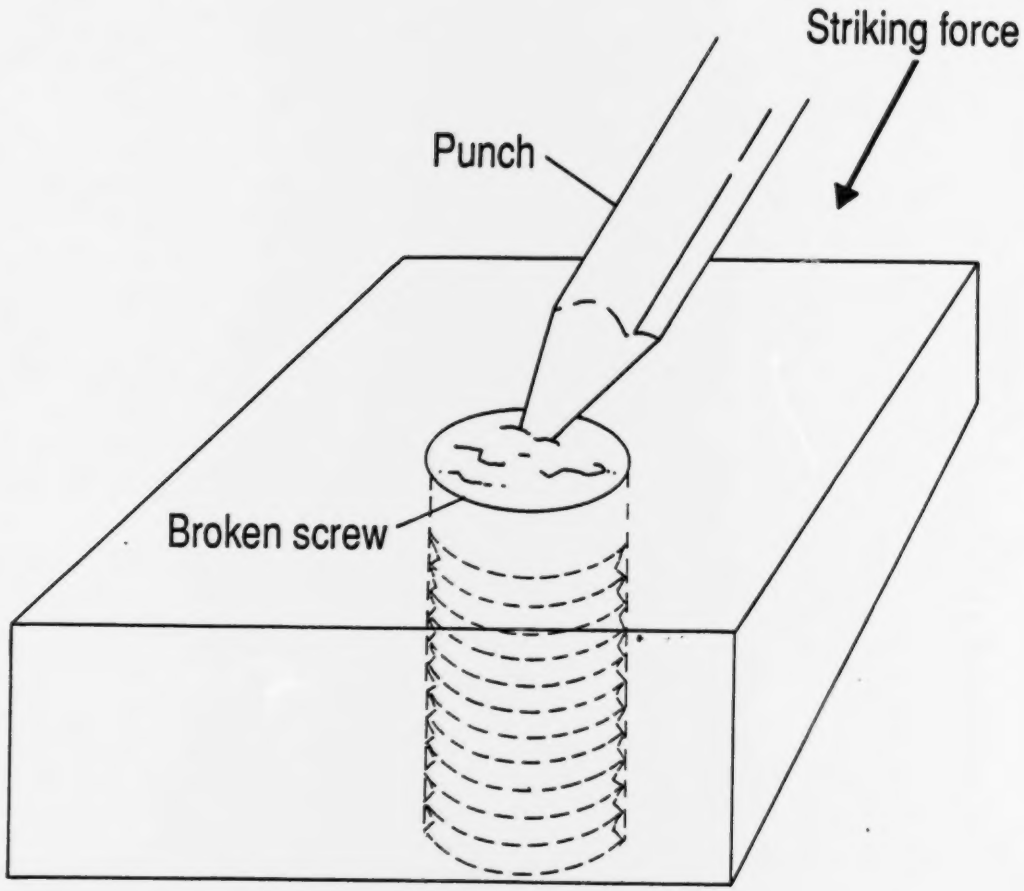
   CAUTION: The screw extractor is a hardened tool. Never strike a hardened tool with another hard tool, such as the face of a ball-peen hammer. This can result in breakage and injury.

6. Place drive end of extractor in tap handle. Turn gently with a downward force. Turn counter-clockwise. The broken screw will turn and can be removed from hole.

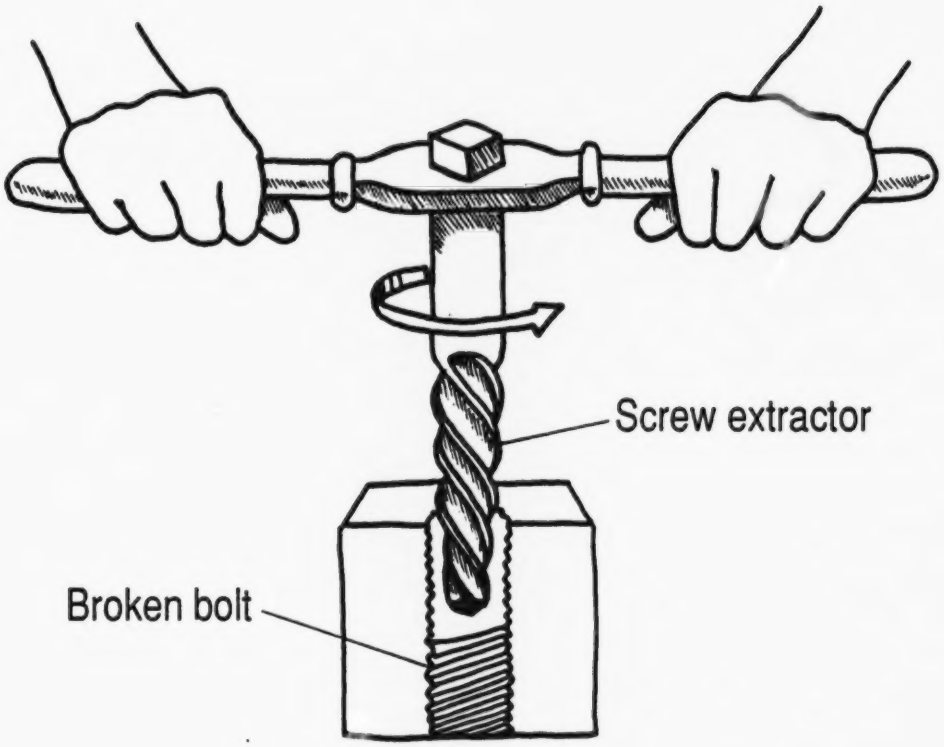
7. Clean the hole and re-thread with a tap matching the original hole specifications.

   NOTE: If threads are stripped or extensively damaged, it may be necessary to enlarge the hole and use a bigger bolt in the application or install a helical coil thread insert.

PUNCH AND HAMMER METHOD



SCREW EXTRACTOR METHOD



REMOVE A BROKEN SCREW USING CENTER PUNCH METHOD

Equipment:

Center punch
10 or 12 oz. ball-peen hammer
Locking pliers
1/4-20 UNC tap
Tap handle
Bench vise
Penetrating oil
Workpiece prepared by instructor

Procedure:	Evaluation 3	2	1	N
CAUTION: Safety goggles must be worn when using center punches, hammers and other striking tools.				
1. Determine if screw is left- or right-handed. Secure workpiece in bench vise. Spray penetrating oil around the broken screw and allow 2-3 minutes for it to work.	—	—	—	—
2. Turn punch at 45° to center axis of the screw so that the punch's point will engage the top of the broken screw.	—	—	—	—
3. Strike punch with hammer in an attempt to force screw to back out of the hole (counter-clockwise for right-hand threads, clockwise for left-hand threads).	—	—	—	—
4. Continue until a small portion of the screw is above the surface of the workpiece. Lock pliers onto the screw and turn until the bolt is completely removed from the hole.	—	—	—	—
5. Carefully run the 1/4-20 tap into and out of the hole to remove any debris and re-shape slightly damaged threads. Be sure to use a few drops of tapping lubricant on the tap to prevent it from seizing and breaking.	—	—	—	—
6. As directed by instructor, prepare for next job sheet or clean up area and return tools and materials.	—	—	—	—
Average of above evaluations*	—	—	—	—

*This average is one-half the student's final evaluation for competency E13: Remove damaged screws.

REMOVE A BROKEN SCREW USING SCREW EXTRACTOR METHOD

Equipment:

Screw extractor set
#2 center drill
7/64 twist drill
Tap handle
10 or 12 oz. ball-peen hammer
3/8" or 1/2" electric hand drill or drill press
Center punch
Penetrating oil
Workpiece prepared by instructor

Procedure:	Evaluation 3	2	1	N
1. Secure workpiece in vise. Spray penetrating oil around the broken screw and allow 2-3 minutes for it to work.	—	—	—	—
2. Using the center punch and hammer, punch a center mark in the center of the damaged screw.	—	—	—	—
NOTE: Do this carefully as the center punch mark guide the drills which are to follow. If the mark is off-center, the drills may damage the workpiece or make it impossible to use the screw extractor effectively.				
3. Select #2 screw extractor, #2 center drill and 7/64" twist drill. Drill damaged screw at the center mark with the center drill and then with the twist drill.	—	—	—	—
4. Insert extractor into drilled hole. It may be necessary to tap the screw extractor lightly with a rubber-faced mallet to seat it in the hole.	—	—	—	—
5. Place drive end of extractor in tap handle. Turn gently with a downward force. Turn counterclockwise. Broken screw will turn and can be removed from hole.	—	—	—	—
6. Carefully run the 1/4-20 tap into and back out of the hole to remove any debris and re-shape slightly damaged threads. Be sure to use a few drops of tapping lubricant on the tap to prevent it from seizing and breaking.	—	—	—	—
7. As directed by instructor, prepare for next job sheet or clean up area and return tools and materials.	—	—	—	—
Average of above evaluations*	—	—	—	—

*This average is the second half of the student's evaluation for competency E13: Remove damaged screws.

MODULE: BENCH WORK AND MATERIAL SCIENCE

UNIT VIII: SCREW, DRILL AND TAP EXTRACTION

LESSON 2: EXTRACTING BROKEN TAPS AND DRILLS

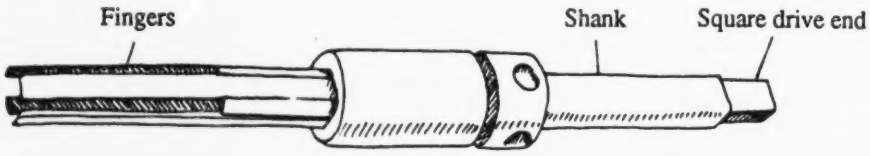
I. Extracting a broken tap

A. Common reasons for breaking taps

1. Improper or no lubricant
2. Material being tapped--Some materials are more difficult to tap. Some materials actually stick to the tool (e.g. copper, certain aluminum alloys, etc.).
3. Turning the tap too fast
4. Moving the tap from side to side rather than turning it
5. Improper tap drill used (hole is too tight)

B. Equipment for broken tap removal

1. Needle-nose pliers
2. Tap extractor and tap handle
3. Pin punch
4. 6-8 oz. ball-peen hammer
5. Penetrating oil



Tap extractor

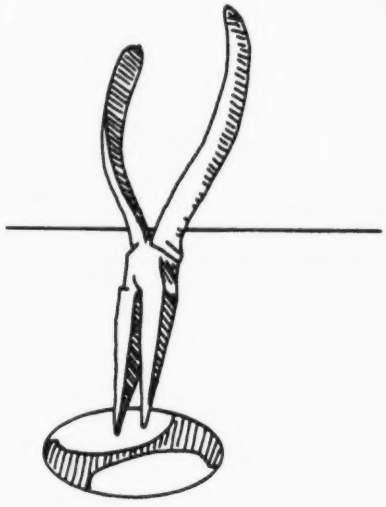
Tap extractor set

C. Procedure

NOTE: Safety glasses must be worn when working with taps.

1. Determine if the tap is right- or left-handed. A right-hand tap is extracted counter-clockwise, while a left-hand tap is clockwise.

2. If the tap was not broken as it was cutting, there is a chance of removing it with slender, needle-nose pliers. This is especially true in the case of a two-flute tap as there is more clearance for the pliers jaws to get around the tap.



3. If pliers will not remove the tap, a tap extractor must be used. The tap extractor has "fingers" which fit into flutes of the tap between the wall of the drilled hole and the tap. Once inserted, a tap handle is placed on the tap extractor and the entire assembly is rotated.

4. If the tap extractor will not work, it may be necessary to break the tap out piece by piece or attempt to drive if out (if is not in a blind hole). A small pin punch is used to break the tap or drive it out.

   CAUTION: This procedure presents a serious eye injury hazard. Full goggles should be worn, and no unprotected individuals should be allowed in the vicinity. When the tap is struck with a punch, it will shatter.

5. When the tap is removed, the hole should be carefully finished with a tap matching the original specification.

II. Installing a helical coil thread insert

A. A helical coil thread insert is a spring-like piece of steel which can be inserted into a hole to replace worn or damaged threads or to provide threads of greater strength in soft materials.

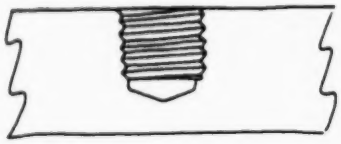
B. The use of helical coil thread inserts can often save an expensive part from being rejected or scrapped.

C. Equipment required is as follows.

1. Taps and tap handle
2. Assortment of helical thread inserts
3. Pliers
4. Drill press and drills
5. Penetrating oil

D. Use the following procedure to install a helical coil thread insert.

1. Secure workpiece in vise.
2. Select tap drill and tap for insert to be used.
3. Carefully drill hole and tap.



NOTE: It is critical that the insert's hole center be aligned with the center of the original hole; if not, the location of the helical coil insert may not meet specifications for the original hole location.

4. Clean out tapped hole and install insert with pliers.

III. Removing broken drills

A. Causes of broken drills

1. Drill is dull
2. Drill is not operated properly
3. No cutting fluid is used

B. Equipment required

1. Drills and drill press
2. Pliers
3. Pin punches
4. 10-12 oz. ball-peen hammer
5. Penetrating oil

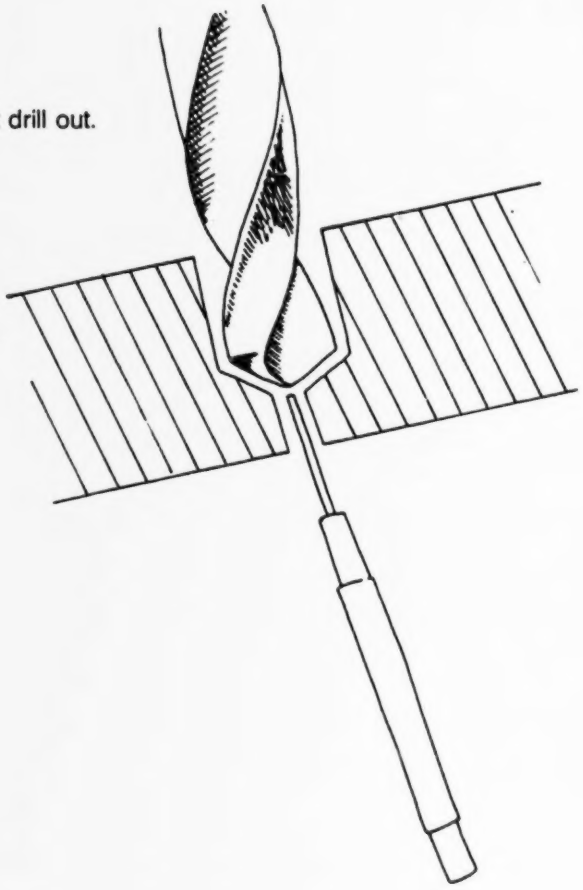
C. Procedure

1. Check size of broken drill

2. Use pliers, if possible, to lift or twist drill out.

3. If a through pilot hole is available or can be made without ruining the workpiece, a pin punch can be used to drive out the broken drill.

   CAUTION: This procedure presents a serious eye injury hazard. Full goggles should be worn and no unprotected individuals should be in the vicinity. When the drill is struck with a punch, it can shatter.



REMOVE A BROKEN DRILL

Equipment:

Drills and drill press
Pliers
Pin punches
10-12 oz. ball-peen hammer

Procedure:	Evaluation 3	2	1	N
1. Check size of broken drill. Secure workpiece in bench vise. Spray penetrating oil around the broken drill and allow 2-3 minutes for it to work.	—	—	—	—
2. Use pliers, if possible, to lift or twist drill out. Do not apply excessive force with pliers as this can cause the drill to break off.	—	—	—	—
3. If a through pilot hole is available or can be made without ruining the workpiece, a pin punch can be used to drive out the broken drill.	—	—	—	—
CAUTION: This procedure presents a serious eye injury hazard. Full goggles should be worn, and no unprotected individuals should be allowed in the vicinity. When the drill is struck with a punch, it can shatter.				
4. Clean up area and return tools and materials.	—	—	—	—
Average of above evaluations*	—	—	—	—

*This average is one-half of the student's evaluation for competency E14: Remove broken drills and taps.

REMOVE A BROKEN TAP

Equipment:

Needle-nose pliers
Tap extractor and tap handle
Pin punch set
6-8 oz. ball-peen hammer
1/4-20 tap
Penetrating oil
Workpiece prepared by instructor

Procedure:	Evaluation 3	2	1	N
NOTE: Safety glasses must be worn when working with taps.				
1. Determine if the tap is right- or left-handed. A right-hand tap is extracted counter-clockwise; a left-hand tap clockwise. Secure workpiece in bench vise. Spray penetrating oil around the broken tap and allow 2-3 minutes for it to work.	—	—	—	—
2. If the tap was not broken while cutting, there may be a chance of removing it with slender, needle-nose pliers. This is especially true in the case of a two-flute tap since there is more clearance for the jaws of the pliers to get around the tap.	—	—	—	—
3. If pliers will not remove the tap, a tap extractor must be used. The tap extractor has "fingers" which fit into flutes of the tap between the wall of the drilled hole and the tap. Once inserted, a tap handle is placed on the tap extractor and the entire assembly is rotated.	—	—	—	—
4. If the tap extractor will not work, it may be necessary to break the tap out piece by piece or attempt to drive if out (if is not in a blind hole). A small pin punch is used to break the tap or drive it out.	—	—	—	—
CAUTION: This procedure presents a serious eye injury hazard. Full goggles should be worn and no unprotected individuals should be in the vicinity. When the tap is struck with a punch, it will shatter.				
5. When the tap is removed, the hole should be carefully finished with 1/4-20 tap.	—	—	—	—
6. As directed by instructor, prepare for next job sheet or clean up area and return tools and materials.	—	—	—	—
Average of above evaluations*	—	—	—	—

*This average is the second half of the student's evaluation for competency E14: Remove broken drills and taps.

INSTALL A HELICAL COIL THREAD INSERT

Equipment:

Taps and tap handle
Assortment of helical thread inserts
Pliers
Drill press and drills

Procedure:	Evaluation 3	2	1	N
1. Secure workpiece in drill press vise.	—	—	—	—
2. Select tap drill and tap for 1/4-20 insert (see chart provided by manufacturer).	—	—	—	—
3. Carefully drill hole and tap.	—	—	—	—
NOTE: It is critical that the insert's hole center be aligned with the center of the original hole or the location of the helical coil insert may not meet specifications for the original hole location.				
4. Clean out tapped hole and install insert with pliers. A few drops of sewing machine oil on the insert will make it easier to install.	—	—	—	—
5. As directed by instructor, prepare for next job sheet or clean up area and return tools and materials.	—	—	—	—
Average of above evaluations*	—	—	—	—

*This average is one-half of the student's final evaluation for competency E16: Install a helical coil thread insert.

MODULE: BENCH WORK AND MATERIAL SCIENCE

UNIT VIII: SCREW, DRILL AND TAP EXTRACTION

UNIT TEST

Select the option which best answers the question or completes the statement.

___ 1. When removing a broken screw by the center punch method, which piece of safety equipment below is essential?

a. Gloves
b. Face mask
c. Safety goggles
d. Safety shoes
e. None of the above

___ 2. After successfully turning the broken bolt with the center punch, what is the next step?

a. Install a helical coil insert.
b. Use a drill press.
c. Get a bigger hammer.
d. Fix locking pliers to the end of the screw and finish removing it.
e. Use a tap extractor.

___ 3. When using a screw extractor, what does the drive end fit?

a. Tap handle
b. Adjustable wrench
c. Pliers
d. Extractor spanner
e. Locking pliers

___ 4. Why is it necessary to exercise care when insert the screw extractor into the broken bolt?

a. The extractor can break.
b. The broken screw can be further damaged.
c. The hole in the screw can become enlarged.
d. The tap handle may not fit the extractor.
e. The lubricant may cause a chemical reaction.

___ 5. After the screw has been removed, what is the final step in the procedure?

a. Use locking pliers to grasp workpiece.
b. Dispose of any unused drills and lubricants.
c. Disassemble tap handle for thorough cleaning.
d. Clean out threads with proper size tap.
e. None of the above

___ 6. If broken screw cannot be removed, which of the following can result?

a. The hole can be redrilled and tapped for a larger size.
b. A helical coil insert can be installed.
c. The workpiece can be scrapped.
d. All of the above
e. None of the above

___ 7. Which of the following is not a cause for a broken tap?

a. Improper or no lubricant
b. Type of material being tapped
c. Sideways motion of the tap handle during tapping
d. Using a two-flute instead of a four-flute tap
e. Turning the tap too fast

___ 8. If the tap has not seized and is fairly loose in the hole, how is it best removed?

a. Center punch
b. Hammer
c. Rubber-faced mallet
d. Screw extractor
e. Needle-nose pliers

___ 9. If a tap extractor method fails, can be tried next?

a. Locking pliers
b. A pin punch and hammer
c. A two flute tap
d. A larger tap handle
e. None of the above

___ 10. Which of the following tools may not be required when installing a helical coil insert?

a. Center punch
b. Drill and drill press
c. Tap
d. Tap handle
e. Assortment of wire inserts

___ 11. Which of the following is commonly used in the removal of broken drills, taps and screws?

a. Ball-peen hammers
b. Tap extractors
c. Screw extractors
d. Penetrating oil
e. Pilot holes

___ 12. Which of the following is not a cause of broken drills?

a. Drill was dull
b. Drill was operated improperly or at wrong speed
c. Tap handle was too large
d. Lack of cutting fluid caused drill to seize
e. None of the above

Listing

13. List the steps of procedure for removing a broken tap.

    a.

    b.

    c.

    d.

    e.

    f.

    g.

14. List the steps of procedure for removing a broken drill.

    a.

    b.

    c.

    d.

    e.

ANSWERS TO UNIT TEST

1. c (E13)
2. d (E13)
3. a (E13)
4. a (E13)
5. d (E13)
6. d (E13, 16)
7. d (E14)
8. e (E14)
9. b (E14)
10. a (E16)
11. d (E13, 14)
12. c (E14)

13. a. Determine if the tap is right-hand or left-hand. (E14)
    b. Secure workpiece in bench vise.
    c. Spray penetrating oil around the broken tap and allow 2-3 minutes for it to work.
    d. Attempt to remove tap with slender, needle-nose pliers.
    e. If pliers do not work, use a tap extractor.
    f. If the tap extractor fails, break the tap out piece-by-piece or attempt to drive if out (if it is not in a blind hole).
    g. When the tap is removed, the hole should be carefully finished with a tap matching the original specification.

14. a. Check size of broken drill. (E14)
    b. Secure workpiece in bench vise.
    c. Spray penetrating oil around the broken drill and allow 2-3 minutes for it to work.
    d. Use pliers, if possible, to lift or twist drill out.
    e. If a through pilot hole is available or can be made without ruining the workpiece, a pin punch can be used to drive out the broken drill.

MODULE: BENCH WORK AND MATERIAL SCIENCE
UNIT IX: ARBOR PRESS OPERATIONS

UNIT OBJECTIVE

In this unit the student will learn and practice various uses for the common shop arbor press, including straightening a workpiece, pressing a shaft into a hole, assembly and disassembly of precision parts, and broaching a keyway. Additionally, the student will learn basic principles of caring for hand tools. This knowledge will be evidenced by achieving the specified score on job sheets and the unit test.

SPECIFIC OBJECTIVES

1.1 Distinguish between types of shop presses.

1.2 Identify shop press uses.

1.3 Identify safety considerations with arbor presses.

1.4 Straighten a bent workpiece using an arbor press. (competency E17, JS 1.1)

1.5 Assemble and disassemble workpiece with arbor press. (competency E18, JS 1.2)

2.1 Identify keyway uses or types.

2.2 Broach a keyway using a broaching set and arbor press. (competency E19, JS 2.1)

3.1 Identify tools used for assembly work.

3.2 Remove and install dowel pins. (competency E15, JS 3.1)

3.3 Disassemble and re-assemble a precision device. (competency E20, JS 3.2)

3.4 Use and care for hand tools. (competency E1, JS 3.2)

MODULE: BENCH WORK AND MATERIAL SCIENCE

UNIT IX: ARBOR PRESS OPERATIONS

CONTENTS OF THIS UNIT

A. Objective sheet

B. References

C. Notes to the instructor

D. Lesson plans

1. Lesson 1: BASIC ARBOR PRESS OPERATIONS

   a. Information outline

   b. Job sheets

      JS 1.1: Straighten workpiece on arbor press
      JS 1.2: Assemble and disassemble workpiece with arbor press

2. Lesson 2: BROACHING AN INTERNAL KEYWAY

   a. Information outline

   b. Transparency master

      TM 2.1: Broaching operation

   c. Job sheets

      JS 2.1: Broach workpiece with broaching tool

3. Lesson 3: ASSEMBLE AND DISASSEMBLE PRECISION PARTS

   a. Information outline

   b. Handout

      HO 3.1: Assembly tools
      HO 3.2: Assembly fasteners

   c. Job sheets

      JS 3.1: Remove and install dowel pins
      JS 3.2: Assemble and disassemble precision parts

E. Unit test

F. Answers to unit test

REFERENCES

A. Books

1. Repp, Victor E., and Willard J. McCarthy. Machine Tool Technology. 5th ed. Bloomington, IL: McKnight Publishing Co., 1984.

2. Repp, Victor E., Willard J. McCarthy and Oswald A. Ludwig. Metalwork Technology and Practice. Bloomington, IL: McKnight Publishing Co., 1982.

B. Curriculum guide

1. Benson, Robert T., and Margaret R. Gregory. V-TECS Guide for Machine Shop. Columbia, SC: South Carolina Department of Education, 1985.

C. Other references

1. Brown, L. "Practical Lapping." Final Finish Technology. Winter 1988: 20-25.

NOTES TO THE INSTRUCTOR

A. Suggested approaches to teaching this unit

1. All job sheets in this unit require a workpiece provided by the instructor. Select workpieces based by available parts and materials on hand.

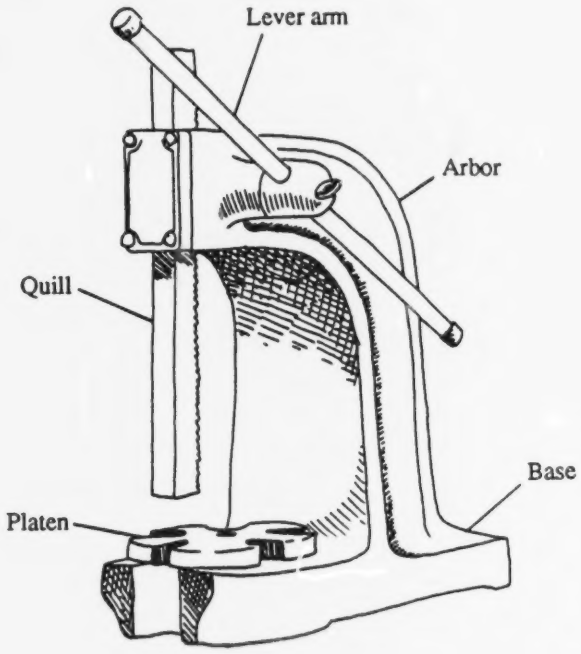
MODULE: BENCH WORK AND MATERIAL SCIENCE

UNIT IX: ARBOR PRESS OPERATIONS

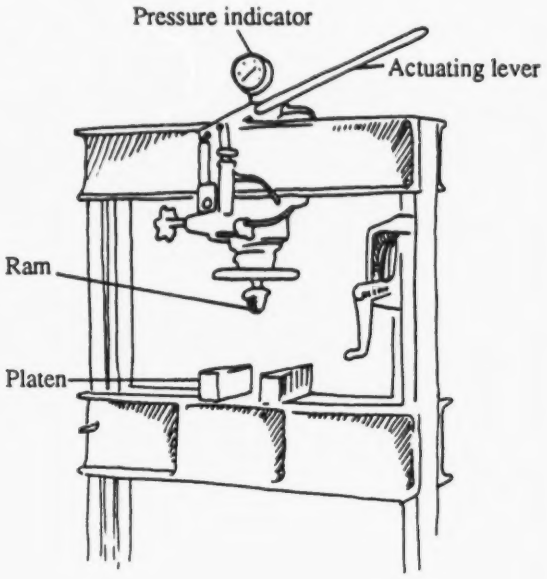
LESSON 1: BASIC ARBOR PRESS OPERATIONS

I. Types of shop presses

A. Mechanical arbor press



B. Hydraulic jack press



II. Uses for the shop press

A. Pressing and removing press fit parts (e.g. bearings, shafts, etc.). Such parts have interference between the mating surfaces, which holds them together.

B. Straightening a bent workpiece

C. Broaching internal keyways

III. Arbor press safety considerations

A. The hydraulic press can generate tremendous forces--up to several tons. Parts must be held flat so they do not suddenly "shoot" out from under the assembly under pressure.

B. Keep fingers clear of the press platen to avoid crushing.

C. Always wear safety glasses when operating a shop press.

D. Keep people not directly involved in the work at hand out of the area.

E. When pressing out a shaft, the area below the press platen must be clear to permit the shaft to fall free when it "breaks loose."

F. Different types of metal have differing amounts of springback (degree to which metal "springs back" to its original shape after forming operations).

STRAIGHTEN WORKPIECE ON ARBOR PRESS

Equipment:

Hydraulic arbor press
Straight-edge and surface plate
Pencil or Prussian blue
Workpiece provided by instructor

Procedure:		Evaluation 3	2	1	N
1.	Place the bent workpiece down on a surface plate in several positions until you determine exactly where the workpiece is bent. Mark this area with a pencil or Prussian blue.	—	—	—	—
2.	Place the workpiece down on the press platen with the high side up; apply pressure with the ram until the workpiece flattens.	—	—	—	—
3.	Release pressure and check with surface plate and straight-edge.	—	—	—	—
	NOTE: Some materials have significant "springback"--when distorted, they tend to return to their original shape. With such materials it may be necessary to bend them beyond the point at which they are straight. Then when pressure is released, they will return to the correct position and be straight.				
4.	Repeat as necessary until workpiece is straight.	—	—	—	—
5.	As directed by instructor, prepare for next job sheet or clean up area and return tools and materials.	—	—	—	—
Average of above evaluations*		—	—	—	—

*This average is the student's final evaluation for competency E17: Straighten workpiece on arbor press.

ASSEMBLE AND DISASSEMBLE WORKPIECE WITH ARBOR PRESS

Equipment:

Arbor press
Double square
Workpiece provided by instructor (shaft and bearing)
Grease

Procedure:	Evaluation 3	2	1	N
Press shaft into hole				
1. Place bearing assembly on arbor press platen. Apply a small amount of grease around the edge of the hole in the assembly.	—	—	—	—
2. Place end of shaft in hole and align with double square on all sides.	—	—	—	—
3. Bring arbor press quill into contact with end of shaft. Check alignment. Press down on arbor press lever, forcing shaft into hole.	—	—	—	—
Remove shaft from hole				
4. Turn assembled bearing and shaft over so that shaft extends below platen of arbor press.	—	—	—	—
5. Bring arbor press quill into contact with end of shaft. Press down on the arbor press lever, forcing shaft down through hole in bearing assembly.	—	—	—	—
6. Arbor press quill will "bottom-out" on bearing. Raise quill and place a short piece of round stock of slightly smaller diameter than the bearing hole on top of the shaft. Press on this stock to force the shaft out.	—	—	—	—
NOTE: Shaft may break loose suddenly. Be sure to have someone catch the shaft so it is not damaged by falling on the floor.				
7. As directed by instructor, prepare for next job sheet or clean up area and return tools and materials.	—	—	—	—
Average of above evaluations*	—	—	—	—

*This average is the student's final evaluation for competency E18: Assemble and disassemble workpiece with arbor press.

MODULE: BENCH WORK AND MATERIAL SCIENCE

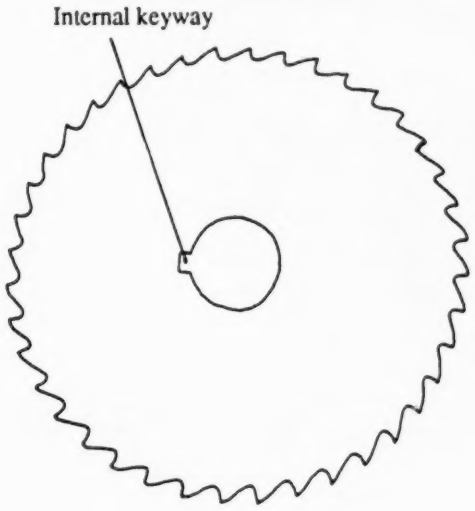
UNIT IX: ARBOR PRESS OPERATIONS

LESSON 2: BROACHING AN INTERNAL KEYWAY

I. Keyways

A. These tools provide a positive drive between two mating parts by use of a key. A key is a square piece of metal which fits into the respective keyways of a shaft and hub (as on a collar or gear).

B. Internal keyways are cut in collars with broaches.



C. External keyways are cut on milling machines.

II. Broaching **(TM 2.1)**

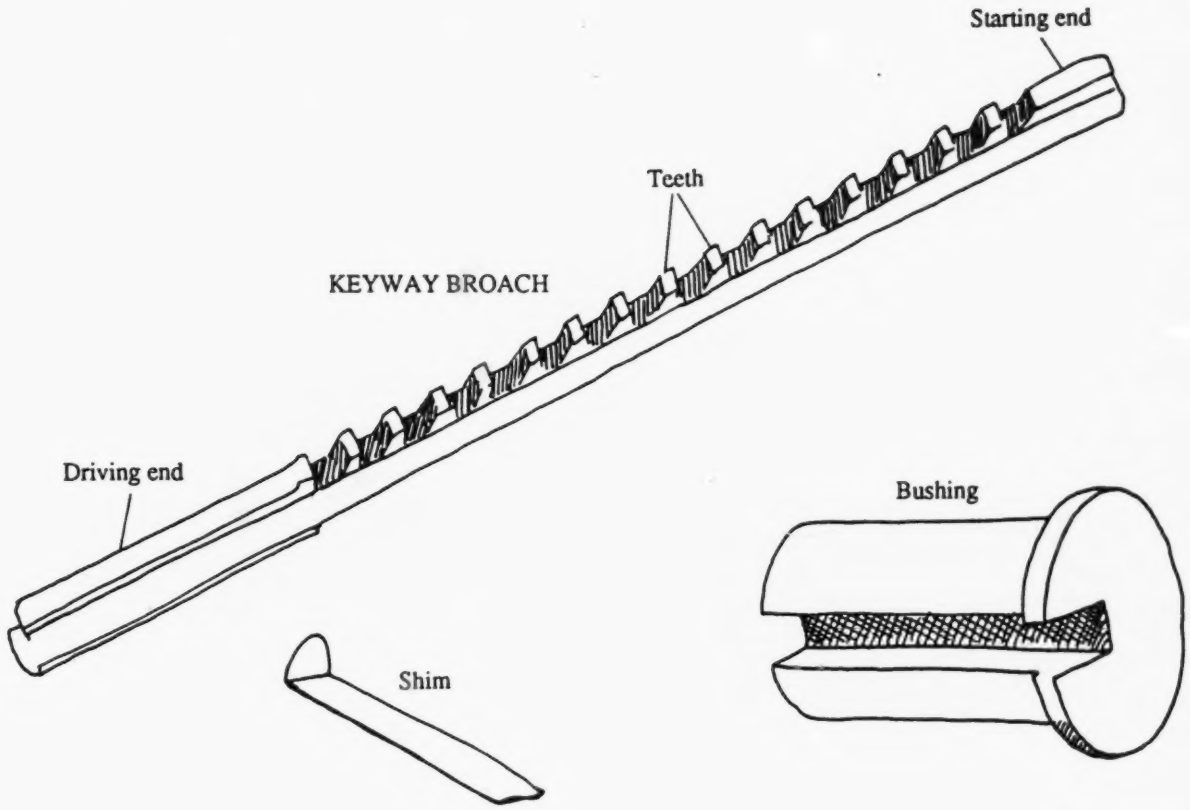
A. A broach is a hardened, tapered cutting tool used with a bushing to cut internal keyways in gears and collars.

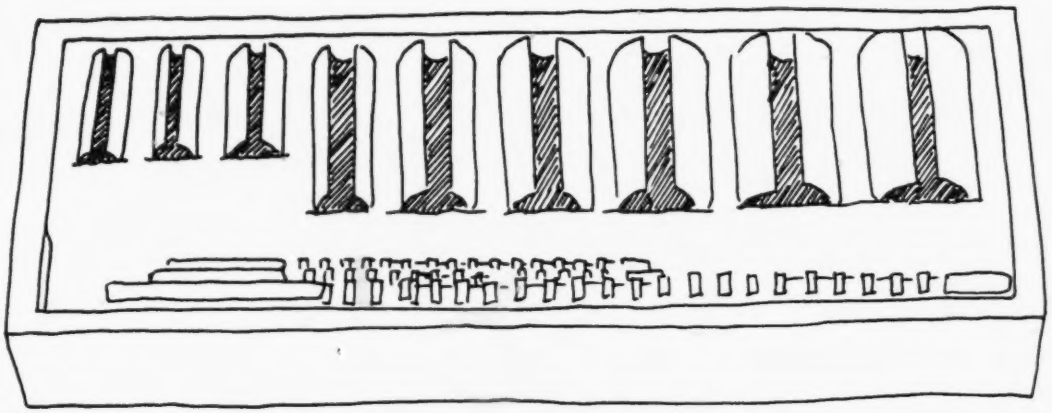
B. The typical broach set consists of the following.

1. Broaches--standard sizes 1/8, 3/16, 1/4, etc.

2. Bushings--fit inside the part and position the broach

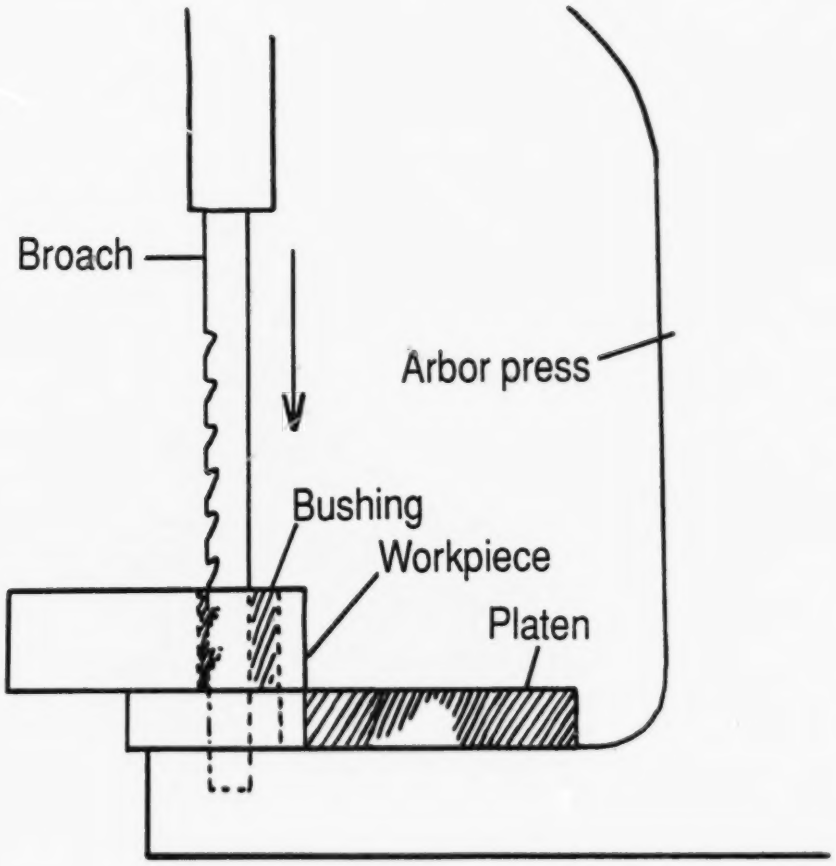
3. Shims--placed behind the broach to cut the keyway to the proper depth





BROACH SET

BROACHING OPERATION



BROACH WORKPIECE WITH BROACHING TOOL

Equipment:

Set of broaches and bushings
Arbor press
Workpiece provided by instructor (gear or collar)
Tapping fluid as appropriate for workpiece material

Procedure:		Evaluation 3	2	1	N
NOTE:	Safety glasses must be worn when working with broaches.				
1.	Select a bushing with an outside diameter that matches the inside diameter of the part to be broached and a slot which accommodates the broach size to be used.	—	—	—	—
2.	Insert bushing into part and place on platen of arbor press.	—	—	—	—
3.	Insert small end of broach into the bushing. Bring quill of arbor press into contact with bushing. Check alignment. Broach must be perpendicular to workpiece or keyway will not be cut straight.	—	—	—	—
4.	Apply a few drops of tapping fluid to the broach and workpiece.	—	—	—	—
5.	Press down on the arbor press lever slowly. Cutting will commence. Stop immediately if excessive pressure is required or if broach binds or is not cutting straight.	—	—	—	—
	CAUTION: Do not let broach drop onto floor. It will be damaged and may break.				
6.	Repeat with successive passes using shims provided in broach kit until desired depth is obtained.	—	—	—	—
7.	As directed by instructor, prepare for next job sheet or clean up area and return tools and materials.	—	—	—	—
Average of above evaluations*		—	—	—	—

*This average is the student's final evaluation for competency E19: Broach workpiece with broaching tool.

MODULE: BENCH WORK AND MATERIAL SCIENCE

UNIT IX: ARBOR PRESS OPERATIONS

LESSON 3: ASSEMBLE AND DISASSEMBLE PRECISION PARTS

I. Tools for assembly **(HO 3.1)**

A. Screwdrivers

1. Standard--for turning standard straight-slot screws
2. Phillips™ (cross-point)--for Phillips head screw. Screwdriver has two slots at right angles to each other; the center of the screw is deeper than the ends.
3. Offset--for working in tight space

B. Pliers

1. Slip joint--general-purpose, adjustable pliers
2. Side cutters--for cutting and bending wire
3. Needle-nose--for holding small parts

C. Wrenches

1. Adjustable wrenches have adjustable jaws.
2. Pipe wrench are for grasping and turning pipe.
3. Spanners are used to turn hubs, tighten chucks, etc.
4. Socket wrenches
5. Hexagon wrenches fit the hole in socket head cap screws.
6. Open-end wrenches
7. Box-end wrenches

D. Punches

1. Use a drift punch to align and loosen pins.
2. Use a pin punch to drive out dowel pins.

E. Striking tools

1. Ball-peen hammer
2. Dead blow hammer--special purpose hammer with soft-face

II. Fasteners for assembly **(HO 3.2)**

A. Pins

1. Dowel pins
2. Taper pins
3. Roll pins

B. Washers (flat and locking)

C. Bolts and screws

1. Types: Carriage, machine, socket head cap screws, set screws
2. Measurement of screws and bolts

D. Nuts

1. Standard--square and hex
2. Wing

E. Keys

1. Plain
2. Woodruff

III. Working with precision assemblies

A. Clean assemblies thoroughly before disassembly

1. Solvent tank
2. Ultrasonic cleaner
3. Blow off with air hose

CAUTION: Use caution when cleaning a part with compressed air. Hold the part close to the floor when applying compressed air. Never point an air hose at anyone.

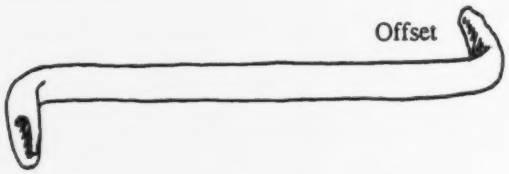
B. Identify fasteners and tools required.

C. Use penetrating oil to loosen seized fasteners.

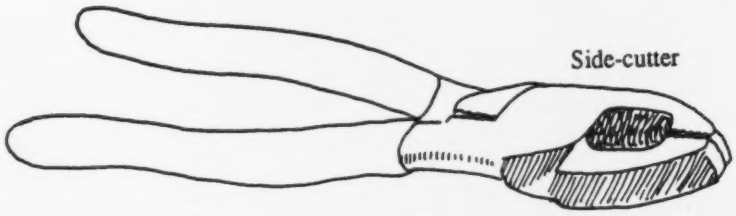
D. Sketch assemblies and sub-assemblies as they are taken apart. Do not rely on memory when re-assembling the product.

ASSEMBLY TOOLS

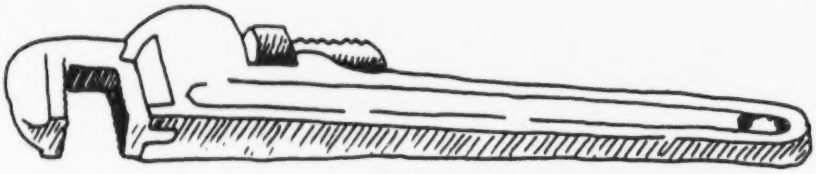
SCREWDRIVERS



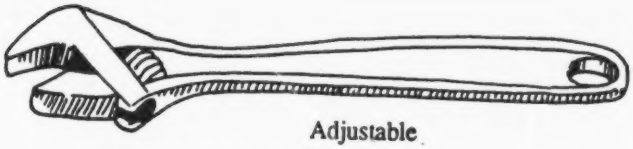
PLIERS



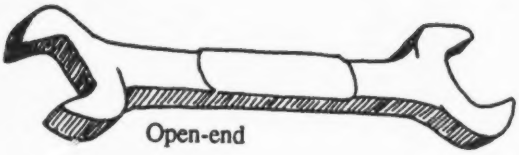
WRENCHES



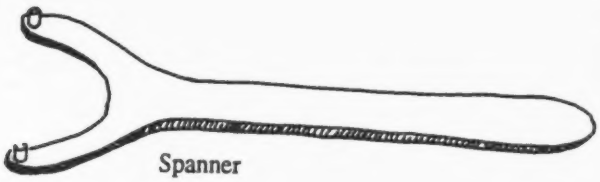
Pipe



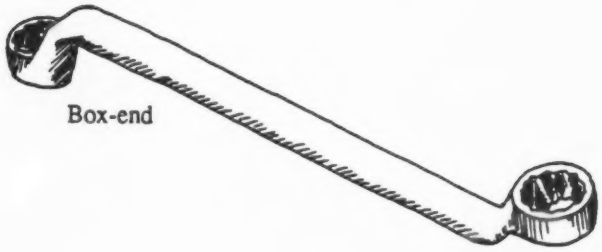
Adjustable



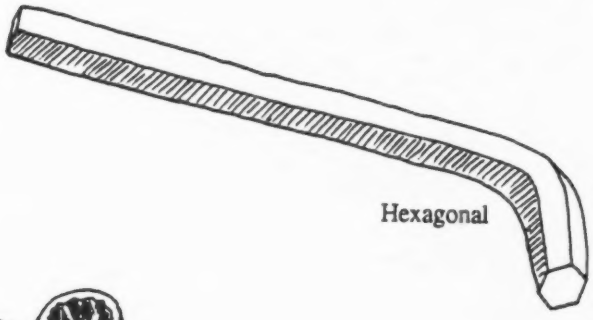
Open-end



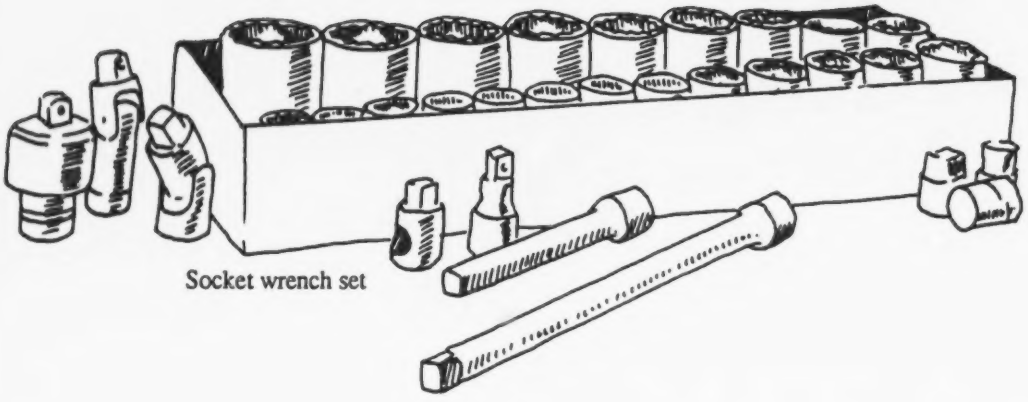
Spanner



Box-end



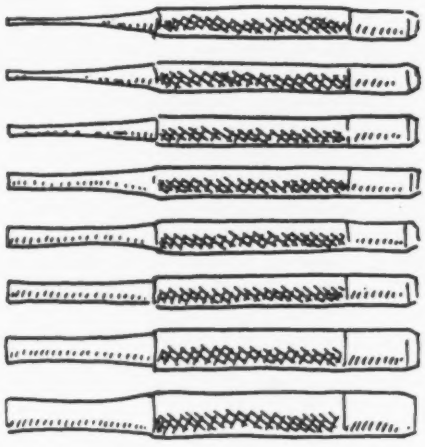
Hexagonal



Socket wrench set

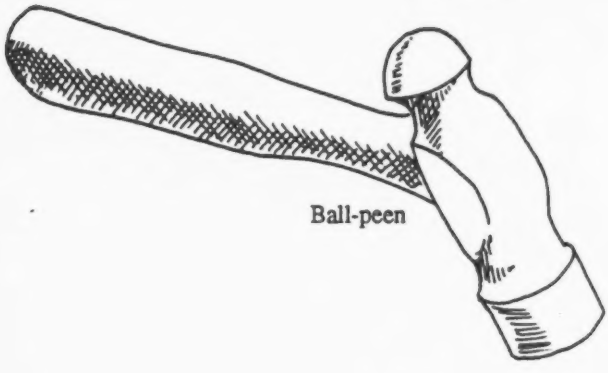
PUNCHES

Drift

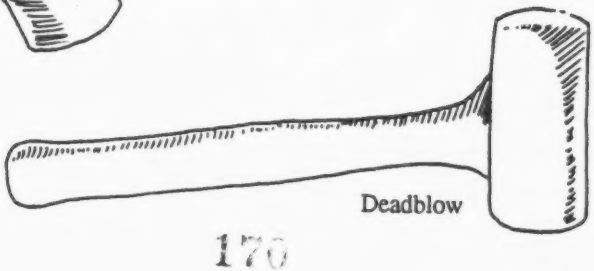


Drive pin -

HAMMERS



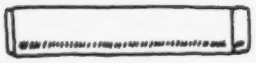
Ball-peen



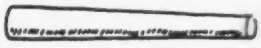
Deadblow

ASSEMBLY FASTENERS

PINS



Dowel



Taper

Roll

WASHERS

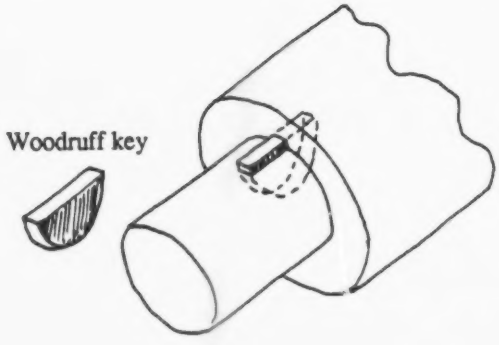
Locking

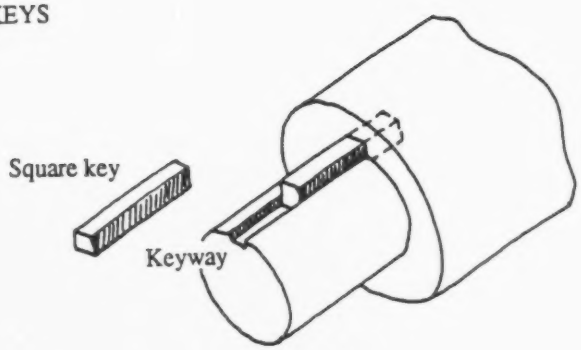
NUTS

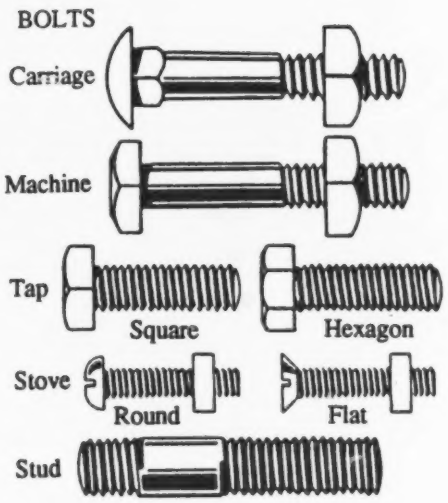
Square

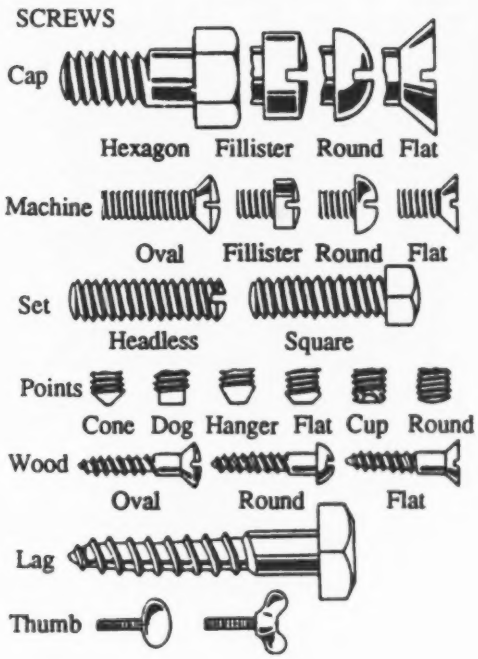
Hexagon

KEYS









Credit: Metalwork Technology and Practice (from the 1989 or earlier editions of this book). Reproduced with permission of the publisher, Glencoe Publishing Company, Mission Hills, Calif. All rights reserved.

REMOVE AND INSTALL DOWEL PINS

Equipment:

Assortment of standard 1" dowel pins (diameters of 1/4", 5/16", 3/8" and 1/2")
Drift punch
Set of pin punches
10-12 oz. ball-peen hammer
Workpiece provided by instructor

Procedure:		Evaluation 3	2	1	N
1.	Secure workpiece in bench vise.	—	—	—	—
2.	Drive in dowel pins using ball-peen hammer beginning with the 1/4" and working through the 1/2". Excessive force should not be required. If dowel pins do not go in easily holes may be too small. Do not force them in as they may break.	—	—	—	—
3.	Turn workpiece over and secure in vise.	—	—	—	—
4.	Using drift punch and hammer, tap each dowel pin to break it loose. Select the largest pin punch from the set which will fit in each hole; drive out the pins.	—	—	—	—
	NOTE: As pins are about to come out, do not strike them hard. They can fly out and cause injury.				
5.	As directed by instructor, prepare for next job sheet or clean up area and return tools and materials.	—	—	—	—
Average of above evaluations*		—	—	—	—

*This average is the student's final evaluation for competency E15: Remove and install dowel pins.

ASSEMBLE AND DISASSEMBLE PRECISION PARTS

Equipment:

Set of mechanics tools
Sketching materials (pencil, paper, straight edge)
Workpiece assembly provided by instructor
Penetrating oil
Solvent cleaning tank
Plastic sandwich bags

Procedure:		Evaluation 3	2	1	N
1.	Clean the product in the solvent tank.	—	—	—	—
2.	Make sketch of assembled product.	—	—	—	—
3.	Begin disassembly of product using appropriate tools. Use penetrating oil on corroded or seized components. Make sketches of subassemblies. Group and place small parts in plastic bags.	—	—	—	—
4.	Sketch all small parts and subassemblies. Identify each type of fastener used.	—	—	—	—
5.	Working from sketches, reassemble the product. Put all tools away. Present product and work area to the instructor for inspection.	—	—	—	—
Average of above evaluations*		—	—	—	—

*This average is the student's final evaluation for competencies E1 and E20.

MODULE: BENCH WORK AND MATERIAL SCIENCE

UNIT IX: ARBOR PRESS OPERATIONS

UNIT TEST

Select the option which best answers the question or completes the statement.

___ 1. Which of the following is not a use for a shop press?

a. Pressing shafts and bearings
b. Broaching internal keyways
c. Straightening a bent workpiece
d. Drilling holes
e. Assembly and disassembly of parts

___ 2. Identify the term denoting the tendency of some materials to return to their original shape when distorted.

a. Springback
b. Tensile strength
c. Bearing material
d. Interference
e. None of the above

___ 3. Which of the following provides a positive drive between two mating parts?

a. Keyway
b. Broach
c. Arbor press
d. Shop press
e. Springback

___ 4. Which of the following is not an arbor press safety consideration?

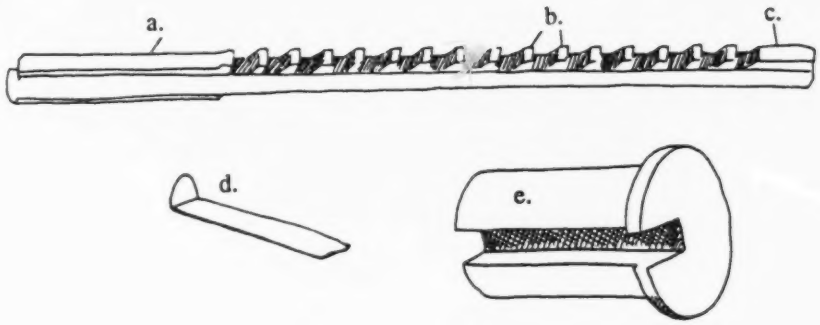
a. Hold parts flat.
b. Keep fingers clear of the press platen.
c. Always wear safety glasses when operating a shop press.
d. Keep people not directly involved in the work out of the area.
e. When pressing out a shaft, keep the area to the side of the press platen clear.

___ 5. Which part is found on a hydraulic jack press but not on an arbor press?

a. Lever arm
b. Arbor
c. Platen
d. Pressure indicator
e. Base

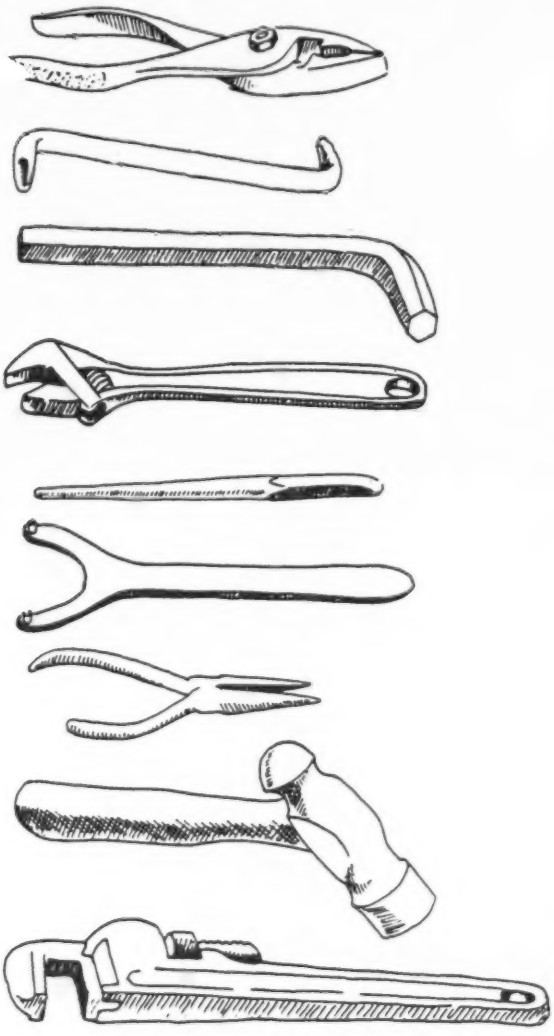
Identify the parts of the broach shown below.

6. Bushing
7. Drive end
8. Shim



Identify the assembly tools shown below.

___ 9.
___ 10.
___ 11.
___ 12.
___ 13.
___ 14.
___ 15.
___ 16.
___ 17.



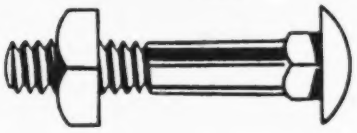
a. Adjustable wrench
b. Ball-peen hammer
c. Box-end wrench
d. Dead blow hammer
e. Drift punch
ab. Drive pin punch
ac. Hex wrench
ad. Needle-nose pliers
ae. Offset screwdriver
bc. Open-end wrench
bd. Phillips™ screwdriver
be. Pipe wrench
cd. Side-cutter pliers
ce. Slip-joint pliers
de. Spanner

Identify the fasteners shown below.

___ 18.

___ 19.

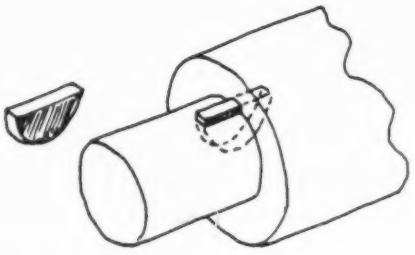
___ 20.



___ 21.

___ 22.

___ 23.



a. Carriage bolt
b. Dowel pin
c. Flat washer
d. Lag bolt
e. Lock washer
ab. Machine screw
ac. Machine bolt
ad. Roll pin
ae. Set screw
bc. Square key
bd. Taper pin
be. Thumb screw
cd. Wood screw
ce. Woodruff key

ANSWERS TO UNIT TEST

1.	d	(E17-20)
2.	a	(E17)
3.	a	(E19)
4.	e	(E17)
5.	d	(E17)
6.	e	(E17)
7.	a	(E19)
8.	d	(E19)
9.	ce	(E1, E20)
10.	ae	(E1, E20)
11.	ac	(E1, E20)
12.	a	(E1, E20)
13.	e	(E1, E20)
14.	de	(E1, E20)
15.	ad	(E1, E20)
16.	b	(E1, E20)
17.	be	(E1, E20)
18.	ad	(E1, E20)
19.	ae	(E1, E20)
20.	a	(E1, E20)
21.	e	(E1, E20)
22.	d	(E1, E20)
23.	ce	(E1, E20)

MODULE: BENCH WORK AND MATERIAL SCIENCE

UNIT X: TYPES OF MATERIALS

UNIT OBJECTIVE

Upon completion of this unit, the student should be able to identify types of metals and related materials; distinguish between ferrous, nonferrous and nonmetallic materials; and list properties that affect machinability and major cutting tool variables. This knowledge will be evidenced by achieving the specified score on the assignment sheet and unit test.

SPECIFIC OBJECTIVES

Upon completion of this unit, the student will be able to:

1.1 Match terms and definitions associated with materials and machinability. (competency F2)

1.2 Identify types of metals and related materials. (competency F1)

MODULE: BENCH WORK AND MATERIAL SCIENCE

UNIT X: TYPES OF MATERIALS

CONTENTS OF THIS UNIT

A. Objective sheet

B. References

C. Notes to the instructor

D. Lesson plan

1. Lesson 1: TYPES OF MATERIALS

   a. Information outline

   b. Handout

      HO 1.1: Identifying metals

   c. Assignment sheet

      AS 1.1: Metal identification

   d. Answers to assignment sheet

E. Unit test

F. Answers to unit test

REFERENCES

A. Books

1. Modern Steels and Their Properties (Handbook 3310). Bethlehem, PA: Bethlehem Steel, 1978.

2. Allen, D. K. Metallurgy Theory and Practice. Chicago: American Technical Society, 1971.

3. Kibbe, Richard R. Grinding Machine Operations. New York: John Wiley and Sons, 1985.

B. Curriculum guides

1. Dunn, James. Machine Shop Lathes. Stillwater: Curriculum and Instructional Materials Center, Oklahoma State Board of Vocational and Technical Education, 1983.

2. Yettaw, Jerome. Vocational Machine Shop. University of Missouri-Columbia: Instructional Materials Laboratory, 1977.

NOTES TO THE INSTRUCTOR

A. Suggested approaches to teaching this unit

1. Because competencies F2 and F4 are closely related to competencies H5, I4 and J8, information and tests over cutting tool variables have been presented primarily in Unit VI of the Lathes module. The instructor should refer to that unit when evaluating students on competencies F2 and F4.

B. Suggested student activities

1. Using HO 1.1, have students practice identifying types of materials found in the shop. AS 1.1 can also be used to identify materials.

2. Review/study Unit VI of the Lathes module for instruction related to competencies F2 and F4.

C. Suggested supplemental materials

1. Baril, Richard. Modern Machining Technology. Albany, NY: Delmar Publishers, Inc., 1987.

2. Hardman, William E. Basic Machine Shop Theory. Ft. Washington, MD: National Tool and Precision Machining Association, 1982.

3. Repp, Victor E., and Willard J. McCarthy. Machine Tool Technology. 5th ed. Bloomington, IL: McKnight Publishing Co., 1984.

MODULE: BENCH WORK AND MATERIAL SCIENCE

UNIT X: TYPES OF MATERIALS

LESSON 1: TYPES OF MATERIALS

I. Terms and definitions

A. AISI (American Iron and Steel Institute)--professional group that sets standards for steel

B. Allowable cutting speed--gives maximum tool life between grindings with maximum chip or material removed

C. Cutting speed--number of feet of material passing the cutting edge per minute

D. Ferrous--metal with iron as its major element; usually magnetic

E. Machinability--ease with which a material can be machined. A material's machinability is defined by its rating on the machinability index with respect to reference material AISI 1112 (cold drawn steel). The machinability index of AISI 1112 is given as 100%. The rating of other materials is given as a percentage greater or less than 100%. This index is a composite of various factors, including force required to machine, surface finish, tool life, cutting speed, etc.

F. Metallic--metal material (ferrous or nonferrous)

G. Nonferrous--metal that does not contain iron; not magnetic

H. Nonmetallic--material without metal components

I. SAE (Society of Automotive Engineers)--professional group that sets many manufacturing standards, such as steel and screw threads

J. Sour--coolant having a decayed or rotten smell due to bacterial build-up; bacteria caused by contamination

K. Tool-bit geometry--angles ground on, or angles of, cutting tools; angles vary with material

II. Ferrous, nonferrous and nonmetallic materials **(HO 1.1)**

A. Ferrous metals

1. Tool steel
2. Mild steel
3. Cast iron
4. Stainless steel (type 410)
5. High carbon steel
6. Alloy steel

B. Nonferrous metals

1. Brass

2. Copper

3. Aluminum

4. Bronze

5. Cast aluminum

6. Lead

7. Stainless steel (type 316)

C. Nonmetallic materials

1. Wood

2. Plastic (i.e., nylon, Teflon™)

3. Glass

4. Rubber

5. Ceramic

D. Effect of different materials on tool geometry

1. With soft metals, more side clearance and side rake must be ground on the tool so it has a shearing action.

2. Tool shapes, high-speed steels and carbide tools are discussed in more detail in the Lathe module.

HO 1.1 - IDENTIFYING METALS

Metal	Surface appearance	Magnetic test	Chisel test	Fracture test	Heat test	Spark test
Low carbon steel	Dark gray	Strongly magnetic	Continuous chip; smooth edges; chips easily	Bright gray	Melts fast. Becomes bright red before melting.	Gives off a long straight line of white sparks with bursts at the end
Medium carbon steel	Dark gray	Strongly magnetic	Continuous chip; smooth edges; chips easily	Very light gray	Melts fast. Becomes bright red before melting.	Gives off lots of yellow sparks with bursts at the end
High carbon steel	Dark gray	Strongly magnetic	Hard to chip; can be continuous	Very light gray	Melts fast. Becomes bright red before melting.	Gives off white line of sparks with star bursts
Cast iron	Dull gray	Strongly magnetic	Not easily chipped; chips break off in small pieces.	Dark gray; porous	Melts slowly; becomes dull red before melting.	Red sparks near the grinding wheel that turn yellow toward the end of the stream
Stainless steel	Bright silver, smooth	Slightly magnetic; high quality is non-magnetic	Relatively hard to chip	Bright gray; smooth	Melts fast; becomes bright red before melting.	Gives off a stream of yellow sparks that fork at the end
Wrought iron	Light gray, smooth surface	Strongly magnetic	Chips easily; smooth continuous chip	Bright gray	Melts fast.	Many sparks yellow at the wheel and forked at the end
Aluminum*	Silver-white	Not applicable	Easily chipped; smooth chip often continuous	White	Melts fast. Becomes shiny when melted.	Not applicable
Bronze*	Opaque yellow	Not applicable	Easily chipped; smooth chip often continuous	Red to yellow	Melts fast.	Not applicable
Brass*	Reddish (5-10% zinc) Yellowish (2-36% zinc)	Not applicable	Easily chipped; smooth chip often continuous	Red to yellow	Melts fast.	Not applicable

*Nonferrous metals

185

METAL IDENTIFICATION

Identify types of metals and materials by matching the class to the materials.

____ 1.	Cast iron	a.	Ferrous
____ 2.	Lead	b.	Nonferrous
____ 3.	Glass	c.	Nonmetallic
____ 4.	Alloy steel		
____ 5.	Bronze		
____ 6.	Brass		

Select the option which best answers the question or completes the statement.

____ 7. Which type of test is most effective in identifying aluminum because of the material's color?

a. Magnetic
b. Heat
c. Spark
d. Fracture

____ 8. Which type of test is most effective in distinguishing high-carbon steel from medium-carbon steel?

a. Magnetic
b. Heat
c. Spark
d. Fracture

____ 9. Which type of test is most effective in distinguishing low-carbon steel from medium-carbon steel?

a. Magnetic
b. Heat
c. Spark
d. Chisel

ANSWERS TO AS 1.1 (F1)

1. a
2. b
3. c
4. a
5. b
6. b
7. d
8. c
9. c

MODULE: BENCH WORK AND MATERIAL SCIENCE

UNIT X: TYPES OF MATERIALS

UNIT TEST

Match terms and definitions associated with materials and cutting fluids.

____	1.	Metal with iron as its major element; usually magnetic	a. AISI
____	2.	Professional group that sets many manufacturing standards, such as steel and screw threads	b. Allowable cutting speed
____	3.	Number of feet of material passing the cutting edge	c. Cutting speed
____	4.	Metal that does not contain iron; not magnetic	d. Ferrous
____	5.	Gives maximum tool life between grindings with maximum chip or material removed	e. Machinability
____	6.	Angles ground on, or angles of, cutting tools; angles vary with material	ab. Metallic
____	7.	Coolant having a decayed or rotten smell due to bacterial build-up; bacteria caused by contamination	ac. Nonferrous
____	8.	Professional group that sets standards for steel	ad. Nonmetallic
____	9.	Material without metal components	ae. SAE
____	10.	Ease with which a material can be machined	bc. Sour
			bd. Tool-bit geometry

Distinguish between each of the following by matching the appropriate class to the material.

____	11.	Mild steel	a.	Ferrous	
____	12.	Lead	b.	Nonferrous	
____	13.	Wood	c.	Nonmetallic	
____	14.	Aluminum			
____	15.	Rubber			
____	16.	Stainless steel			
____	17.	Plastic	____	21.	High-carbon steel
____	18.	Tool steel	____	22.	Cast aluminum
____	19.	Copper	____	23.	Alloy steel
____	20.	Ceramic	____	24.	Bronze

Short answer

25. List two factors that affect or define a material's machinability.

a.

b.

NOTE: Completion of this unit test to specified score is the student's final evaluation for F1 and partial evaluation for F2.

ANSWERS TO UNIT TEST

1. d
2. ae
3. c
4. ac
5. b
6. bd
7. bc
8. a
9. ad
10. e (F2)
11. a (F1)
12. b (F1)
13. c (F1)
14. b (F1)
15. c (F1)
16. a or b (F1)
17. c (F1)
18. a (F1)
19. b (F1)
20. c (F1)
21. a (F1)
22. b (F1)
23. a (F1)
24. b (F1)

25. Any two of the following: (F2)

    a. Its rating on the machinability index
    b. Force required to machine
    c. Surface finish
    d. Tool life
    e. Cutting speed

MODULE: BENCH WORK AND MATERIAL SCIENCE
UNIT XI: TESTING AND HARDENING MATERIALS

UNIT OBJECTIVE

Upon completion of this unit, the student should be able to identify, test and harden materials. The student should also be able to match heat treatment definitions and safety precautions. This knowledge will be evidenced by achieving the specified score on job sheets and the unit test.

SPECIFIC OBJECTIVES

1.1 Identify carbon content of steel from the SAE/AISI numbering system.

1.2 Describe factors that affect cutting speeds and tool-bit geometry.

1.3 Match definitions with methods for testing for hardness and carbon content of steels.

1.4 Match terms and definitions related to heat treating.

1.5 Complete safety precautions for heat treatment.

1.6 Demonstrate the ability to:

a. Correlate types of materials to properties. (competency F3, JS 1.1)

b. Test workpiece for hardness without hardness tester. (competency F6, JS 1.2)

c. Perform heat treatment process. (competency F5, JS 1.3)

MODULE: BENCH WORK AND MATERIAL SCIENCE

UNIT XI: TESTING AND HARDENING MATERIALS

CONTENTS OF THIS UNIT

A. Objective sheet

B. References

C. Notes to the instructor

D. Lesson plan

1. Lesson 1: CUTTING TOOLS AND TESTING PROCEDURES

   a. Information outline

   b. Transparency masters

      TM 1.1: Types of heating mediums
      TM 1.2: Protective equipment

   c. Handouts

      HO 1.1: SAE/AISI numbering systems
      HO 1.2: Cutting speeds (CS)

   d. Assignment sheet

      AS 1.1: Types of materials and their properties

   e. Answers to assignment sheet

   f. Job sheets

      JS 1.1: Test workpiece for hardness without hardness tester
      JS 1.2: Case harden low-carbon steel
      JS 1.3: Harden and temper steel

E. Unit test

F. Answers to unit test

REFERENCES

A. Books

1. Modern Steels and Their Properties (Handbook 3310). Bethlehem, PA: Bethlehem Steel, 1978.

2. Kibbe, Richard R. Lathe Operations. New York: John Wiley and Sons, 1985.

B. Curriculum guides

1. Dunn, James. Machine Shop Lathes. Stillwater: Curriculum and Instructional Materials Center, Oklahoma State Board of Vocational and Technical Education, 1983.

2. Yettaw, Jerome. Vocational Machine Shop. University of Missouri-Columbia: Instructional Materials Laboratory, 1977.

NOTES TO THE INSTRUCTOR

A. Suggested supplemental materials

1. Baril, Richard. Modern Machining Technology. Albany, NY: Delmar Publishers, Inc., 1987.

2. Hardman, William E. Basic Machine Shop Theory. Ft. Washington, MD: National Tool and Precision Machining Association, 1982.

3. Oberg, Erik; Franklin D. Jones; Holbrook L. Horton. Machinery's Handbook. 23rd ed. New York: Industrial Press, Inc., 1988.

4. Repp, Victor E., and Willard J. McCarthy. Machine Tool Technology. 5th ed. Bloomington, IL: McKnight Publishing Co., 1984.

MODULE: BENCH WORK AND MATERIAL SCIENCE

UNIT XI: TESTING AND HARDENING MATERIALS

LESSON 1: CUTTING TOOLS AND TESTING PROCEDURES

I. SAE/AISI numbering systems **(HO 1.1, 1.2)**

A. First digit indicates the group of steel.

B. Second digit indicates the percentage of predominate alloy.

C. SAE steel numbering system

Carbon steels	1xxx
Nonsulfurized carbon steels	10xx
Example:	1018
Nickel steels	2xxx
Nickel (3.25-5.25%)	23xx
Example:	2340
Molybdenum steels	4xxx
Molybdenum 0.20 or 0.30%	40xx
Example:	4024
Chromium steels	5xxx
Chromium 0.25, 0.40 or 0.50%	50xx
Chromium (1.45% chromium, 1% carbon)	52100

D. Third and fourth digits indicate the percent of carbon content.

NOTE: The only difference between SAE and AISI numbering systems is the letter that precedes the AISI number. For example, in the number E2517, E denotes electric furnace (while A = open hearth, B = acid bessemer, C = basic open hearth and D = acid open hearth).

Examples:

SAE 1020	SAE 2517
1xxx: Carbon steel group	2xxx: Nickel steel group
10xx: No alloy ingredient	25xx: 5% nickel alloy
1020: .20 of 1% carbon content	2517: .17 of 1% carbon content

II. Factors affecting cutting speeds and tool-bit geometry

A. Machinability of material--level of difficulty or ease in cutting a material

B. Hardness of material--resistance to penetration

C. Toughness of material--resistance to cutting

III. Testing for hardness and carbon content of steels

A. File test--metal is filed and ease or difficulty level is noted

NOTE: Compare different tests in the chart below. Notice that materials above 30-42 Rockwell "C" are almost impossible (or impractical) to machine with high-speed steel.

File test and hardness table

File reaction	Rockwell B	Rockwell C	Brinell	Type of steel
File bites easily into metal	65		100	Mild
File bites into metal with pressure		16	212	Medium carbon
File does not bite into metal except with difficulty		31	294	High alloy, high carbon
Metal can only be filed with extreme pressure		42	390	Tool
File marks metal but metal is nearly as hard as file; filing is impractical		50	481	Hardened tool
Metal is as hard as the file		64	739	Case-hardened parts

B. Spark test--metal displays a particular spark pattern when held against a grinding wheel; sparks are compared with known sample

1. Cast iron

2. High-speed steel

3. High-carbon steel

4. Low-carbon steel

C. Rockwell test--for hardness of materials

1. Uses a carbide ball (B scale) or a cone-shaped, diamond penetrator (C scale)
2. Measures depth of penetration and converts to a standard scale
3. Primarily used for inspection; can also be used to check for machinability

D. Brinell test

1. Uses a ball penetrator to create impression on metal
2. Diameter of impression is measured and converted mathematically

Approximate Rockwell and Brinell hardness numbers for steel*

Brinell indention dia. (mm)	Brinnell hardness no.#	Rockwell B-scale#	Rockwell C-scale#	Tensile strength (1000 psi)	Brinell indention dia. (mm)	Brinell hardness no.#	Rockwell B-scale#	Rockwell C-scale#	Tensile strength (1000 psi)
2.25	(745)		65.3		3.70	269	(104.0)	27.6	895 (130)
2.30	(712)				3.75	262	(103.0)	26.6	875 (127)
2.35	(682)		61.7		3.80	255	(102.0)	25.4	850 (123)
2.40	(653)		60.0		3.85	248	(101.0)	24.2	825 (120)
2.45	627		58.7		3.90	241	100.0	22.8	800 (116)
2.50	601		57.3		3.95	235	99.0	21.7	785 (114)
2.55	578		56.0		4.00	229	98.2	20.5	765 (111)
2.60	555		54.7	2055 (298)	4.05	223	97.3	(18.8)	
2.65	534		53.5	1985 (288)	4.10	217	96.4	(17.5)	725 (105)
2.70	514		52.1	1890 (274)	4.15	212	95.5	(16.0)	705 (102)
2.75	495		51.0	1820 (264)	4.20	207	94.6	(15.2)	690 (100)
2.80	477		49.6	1740 (252)	4.25	201	93.8	(13.8)	675 (98)
2.85	461		48.5	1670 (242)	4.30	197	92.8	(12.7)	655 (95)
2.90	444		47.1	1585 (230)	4.35	192	91.9	(11.5)	640 (93)
2.95	429		45.7	1510 (219)	4.40	187	90.7	(10.0)	620 (90)
3.00	415		44.5	1460 (212)	4.45	183	90.0	(9.0)	615 (89)
3.05	401		43.1	1390 (202)	4.50	179	89.0	(8.0)	600 (87)
3.10	388		41.8	1330 (193)	4.55	174	87.8	(6.4)	585 (85)
3.15	375		40.4	1270 (184)	4.60	170	86.8	(5.4)	570 (83)
3.20	363		39.1	1220 (177)	4.65	167	86.0	(4.4)	560 (81)
3.25	352	(110.0)	37.9	1180 (171)	4.70	163	85.0	(3.3)	545 (79)
3.30	341	(109.0)	36.6	1130 (164)	4.80	156	82.9	(0.9)	525 (76)
3.35	331	(108.5)	35.5	1095 (159)	4.90	149	80.8		505 (73)
3.40	321	(108.0)	34.3	1060 (154)	5.00	143	78.7		490 (71)
3.45	311	(107.5)	33.1	1025 (149)	5.10	137	76.4		460 (67)
3.50	302	(107.0)	32.1	1005 (146)	5.20	131	74.0		450 (65)
3.55	293	(106.0)	30.9	970 (141)	5.30	126	72.0		435 (63)
3.60	285	(105.5)	29.9	950 (138)	5.40	121	69.8		415 (60)
3.65	277	(104.5)	28.8	925 (134)	5.50	116	67.6		400 (58)
					5.60	111	65.7		385 (56)

*This table corresponds to the table in ASM Metals Handbook, 8th ed., Vol. I, pg. 1235.
#Values in parentheses ( ) are beyond normal range and are given for information only.

Credit: Condensed from Table 2, Report J417 (Dec. 1983). Used with permission. © 1984, Society of Automotive Engineers, Inc.

IV. Heat treating terms and definitions **(TM 1.1)**

A. Age harden--material's property to increase in hardness after cooling to room temperature over a period of time

B. Alloy content--important requirement in selecting steels or nonferrous materials for heat treatment and mechanical properties

C. Brittleness--material's property to break easily under impact or shock loading

D. Carbon content--important requirement in the heat treatment of carbon steels (High carbon equals increase in hardness; low carbon equals decrease in hardness.)

E. Corrosion resistance--ability of a material to resist surface oxidation or rusting

F. Critical temperature--temperature at which a material changes from one phase to another to allow for hardening, tempering, stress relief, etc.

G. Deformation--change in shape or physical appearance of a material when it is loaded beyond its elastic limit or heated to extreme temperatures

H. Ductility--material's ability to exhibit plastic deformation without failure

I. Elasticity--ability of a material to return to its original shape or form after removal of an applied load

J. Expansion--property of a material to increase in volume during heating

K. Fatigue--material's failure or fracture under torsion, vibration, bending, etc.

L. Grain structure--visible (under microscope) method of identifying material composition, heat treatments and phase changes in a given material

M. Hardening--property or ability a material exhibits to become harder when heated and quenched above its critical temperature

N. Malleability--ability of a material to exhibit permanent deformation under compression without failure

O. Quenching--use of a medium (air, oil, water, brine, etc.) to cool a heated material to a prescribed temperature

P. Shock resistance--ability of a material to withstand repeated shock loads without failure

Q. Softening--property of an alloy composition or particular heat treatment to relieve hardness in a material

R. Stress relief--heat treatment to decrease a material's internal forces due to rolling, bending, welding, etc., and to decrease amount of cracking and distortion from practical use

S. Tensile strength--material's ability to withstand a maximum load per cross-sectional area under a tension load; usually measured in pounds per square inch (psi).

T. Toughness--material's internal properties which show high strength and resistance to shock, tensile and impact loads

U. Work harden--internal stress built up in a material after rolling, hammering, bending, forging, etc., due to heating, cooling and mechanical working

V. Heat treatment safety precautions **(TM 1.2)**

A. Always wear goggles or a face shield to protect face and eyes while working with heated materials.

B. Always wear an apron, gloves and protective shoes to prevent burns from heated materials.

C. Exercise proper demonstrated procedure in lighting gas furnaces.

D. Always start air flow to gas furnace before turning on gas.

E. If furnace fails to light, clear fumes with air flow before relighting.

F. Know gas valve off and on positions.

G. Shut off electrical circuit before inserting or removing material from an electrical furnace.

H. Use proper size and type of tongs to remove and insert material into a heated furnace.

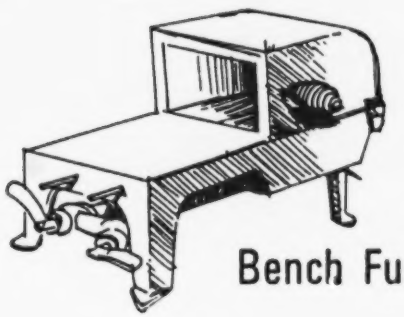
I. Make sure that containers are sturdy and large enough to support material.

J. Use large enough quench tank to prevent overheating of the quenching medium. Oil quenching mediums must be kept below flash-point temperatures.

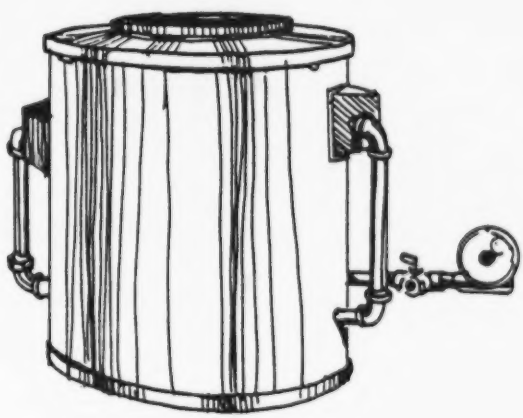
K. Always dry tongs and ladles before using them in a salt-bath solution.

CAUTION: Water will create steam--be careful of hot salt water that may be blown out from a heated bath.

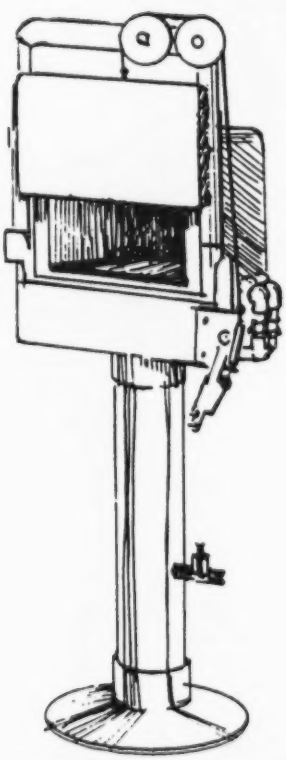
TYPES OF HEATING MEDIUMS



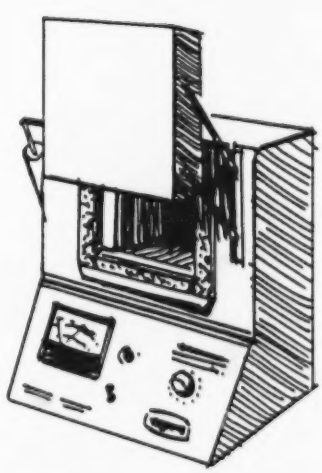
Bench Furnace



Pot Furnace



Gas Furnace



Electric Furnace

PROTECTIVE EQUIPMENT

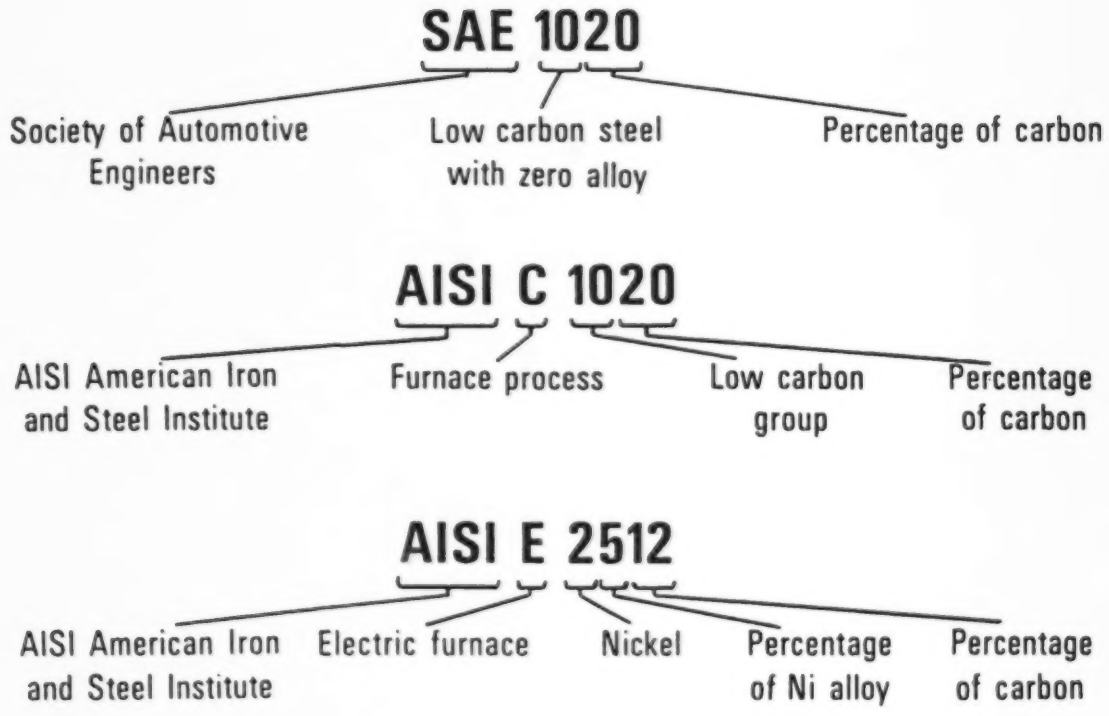
Face shield or goggles

Non-flammable gloves

Non-flammable apron

Hard-soled shoes

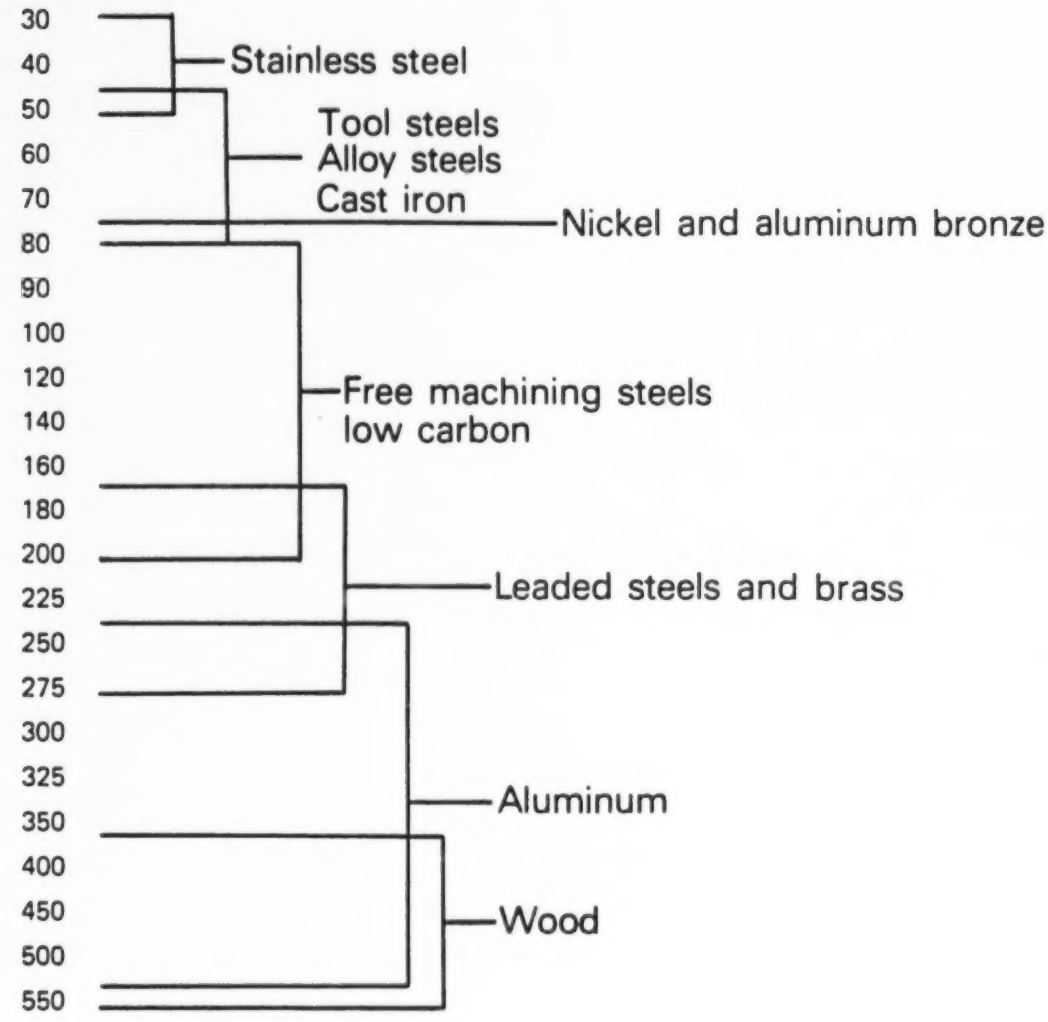
SAE/AISI NUMBERING SYSTEMS



Credit: Dunn, James. Machine Shop I. Stillwater: Curriculum and Instructional Materials Center, Oklahoma State Board of Vocational and Technical Education, 1981, pg. 463B. Used by permission.

CUTTING SPEEDS (CS)

SFM (Surface Feet per Minute)



Credit: Dunn, James. Machine Shop I. Stillwater: Curriculum and Instructional Materials Center, Oklahoma State Board of Vocational and Technical Education, 1981, pg. 463B. Used by permission.

TYPES OF MATERIALS AND THEIR PROPERTIES

Use the tables from HO 1.1 to complete the table below.

	Steel	Carbon content	Cutting speed (cs)
1.	AISI 4140		
2.	SAE 5120		
3.	SAE 1020		
4.	AISI C 1095		
5.	AISI C 1120		
6.	SAE 3145		
7.	SAE 4140		
8.	AISI 303		
9.	SAE 51420F		

NOTE: This assignment sheet is partial fulfillment for competency F3: Correlate types of materials to their properties.

ANSWERS TO AS 1.1

	Carbon content	Cutting speed (cs)
1.	0.38-0.43	70
2.	0.17-0.22	85
3.	0.18-0.23	120
4.	0.90-1.03	100
5.	0.18-0.23	120
6.	0.43-0.48	70
7.	0.38-0.43	70
8.	0.15 maximum	60-90
9.	0.30-0.40	100-130

TEST WORKPIECE FOR HARDNESS WITHOUT HARDNESS TESTER

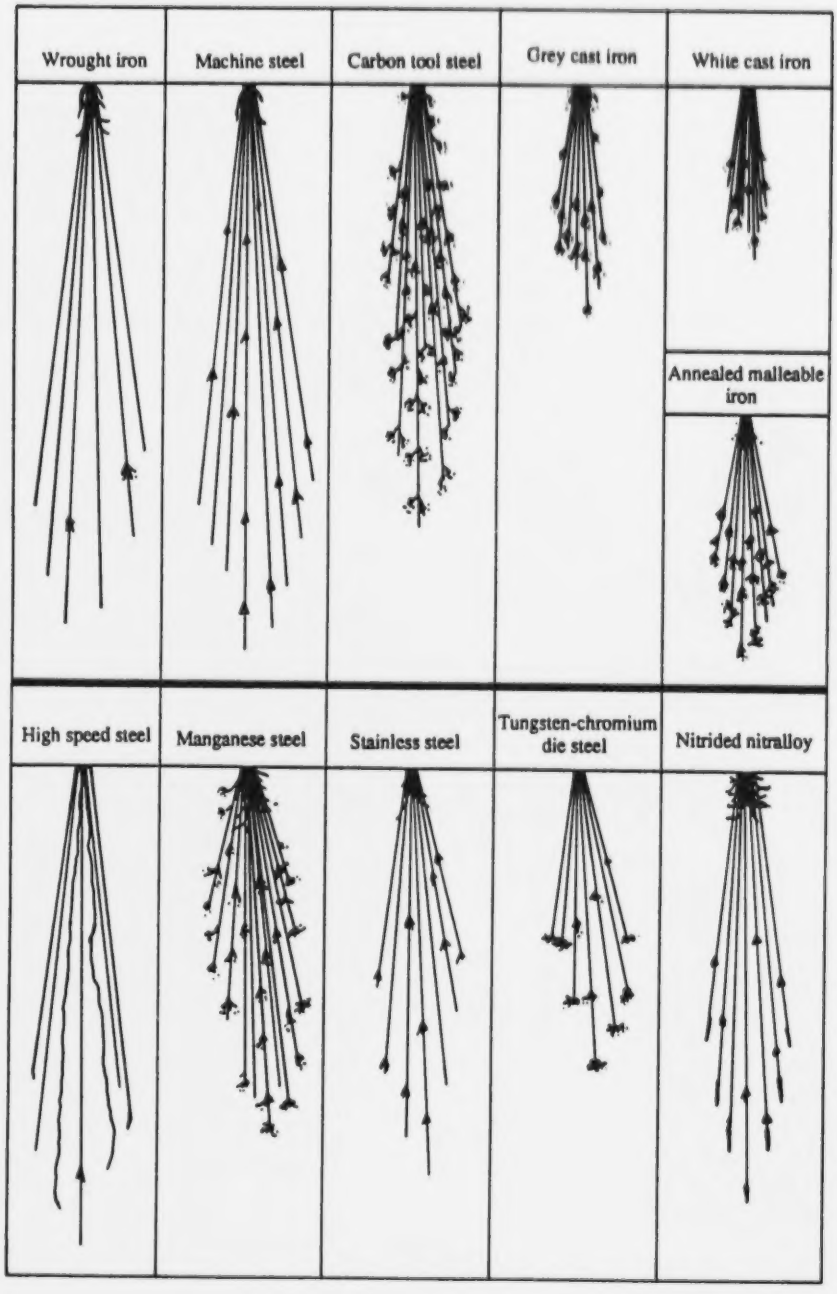
Equipment:

Grinding wheel dresser
Pedestal or bench grinder with coarse stone
Goggles or face shield
File
Metal specimens (five different alloy materials marked with SAE numbers; three unmarked specimens labeled 1, 2 and 3)

Procedure:	Evaluation 3	2	1	N
1. File end of specimen 1; note whether file cuts material easily or with difficulty. File each of the five SAE numbered specimens until one is found that cuts like the first specimen. #1 = SAE _____	—	—	—	—
2. Repeat the above step for the second and third specimens; record results. #2 = SAE _____ #3 = SAE _____	—	—	—	—
3. Put on goggles or face shield. Hold the first specimen high on the face of the stone; apply light pressure against dressing wheel to observe sparks.	—	—	—	—
4. After observing spark pattern, compare results to file test results. If they are not the same, grind on other specimens to find ones that match. Record.	—	—	—	—
5. Use the spark chart on the next page and SAE/AISI numbering systems to see other alloy agents of the steel.	—	—	—	—
6. As directed by instructor, prepare for next job sheet or clean up area and return tools and materials.	—	—	—	—
Average of above evaluations*	—	—	—	—

*This average is the student's final evaluation for competency F6: Test workpiece for hardness without hardness tester.

SPARK TESTS


Wrought iron
Machine steel
Carbon tool steel
Grey cast iron
White cast iron
Annealed malleable iron
High speed steel
Manganese steel
Stainless steel
Tungsten-chromium die steel
Nitrided nitralloy

CASE HARDEN LOW-CARBON STEEL

Equipment:

Furnace (gas or electric)
Low-carbon steel specimen
Protective clothing
Containers
Quenching medium (water)
Carburizing compound (commercial or heat-treating charcoal {bone, charcoal, etc.})
Tongs

NOTE: Use whichever method is more appropriate in your shop.

Procedure:	Evaluation 3	2	1	N
Pack method (better for multiple parts, deeper hardening)				
1. Preheat furnace to 1650°F. Place steel in a shallow container. Cover part with carburizing compound; place a vented cover over the compound, if desired.	—	—	—	—
2. Place container with part into furnace. For an even temperature, allow approximately one hour per inch of cross-sectional area of material.	—	—	—	—
3. Remove part from the container with tongs and quench immediately in clean water, immersing totally. Agitate part in the quenching medium for even cooling.	—	—	—	—
NOTE: If water is heated from repeated quenching, allow it to cool to room temperature or change the water.				
4. Remove scale and compound residue from part's surface.	—	—	—	—
5. Temper part at 300-400°F to obtain a tough core; allow to air-cool. If directed by instructor, check part on Rockwell Tester.	—	—	—	—
Dip method (quicker if hardening few, small parts)				
1. Heat part in furnace to a uniform temperature of 1650°F. (Part should be a bright, cherry red color.)	—	—	—	—
2. With tongs, roll the hot part in carburizing compound until a layer adheres to the outside.	—	—	—	—
3. Place part back in furnace until the layer melts, forming a crust on the outside surface.	—	—	—	—
4. Remove the part; quench immediately in clean, cool water.	—	—	—	—
5. If directed by instructor, check part on Rockwell Tester. (Tempering is usually not required for this method.) If part does not show proper hardness, repeat procedure as many times as is necessary.	—	—	—	—
6. Turn in part to instructor with recorded hardness value. As directed by instructor, prepare for next job sheet or clean up area and return tools and materials.	—	—	—	—

Average of above evaluations* _____

*This average is the student's partial evaluation for competency F5: Perform heat treatment process.

HARDEN AND TEMPER STEEL

Equipment:

Furnace (gas or electric)
Commercial grades of precision-ground flat stock materials (one piece each of oil hardening and air hardening)
Protective clothing
Tongs
Quenching medium (oil, air)

Procedure:	Evaluation 3	2	1	N
Oil hardening				
1. Heat furnace to a uniform temperature of 1500°F. Check specimen hardness on Rockwell C scale.	—	—	—	—
2. Place oil-hardening steel into furnace with tongs. For uniform material temperature, allow heating of one hour per inch of cross-sectional area.	—	—	—	—
3. Remove material from furnace with tongs; quench immediately in oil medium. Immerse part completely and agitate for even, complete cooling.	—	—	—	—
NOTE: For best hardening results, oil should be 120-140°F. Use regular heat-treat quenching oil.				
CAUTION: Do not overheat oil, causing combustion.				
4. If required by instructor, check specimen for hardness on the Rockwell Hardness Tester C scale. Reduce furnace temperature to 800°F. Replace specimen into furnace, allowing one hour of tempering time.	—	—	—	—
5. Remove specimen from furnace with tongs; allow to air-cool on fire brick. When cool, recheck on Rockwell scale (if required). There should be a noticeable decrease in the specimen hardness reading after tempering.	—	—	—	—
CAUTION: Keep specimen away from flammable materials while cooling.				
Air hardening				
6. Heat furnace to a uniform 1750-1800°F. Check hardness of specimen on Rockwell C scale.	—	—	—	—
NOTE: If furnace is not a controlled-atmosphere type, preheat to 1450°F before heating specimen.				
7. Place specimen in furnace with tongs. Heat long enough to obtain an even temperature and color (one hour per inch of cross-sectional area). Do not overheat.	—	—	—	—
8. Remove specimen with tongs. Allow to cool on fire brick in still air.	—	—	—	—
9. Check specimen on Rockwell C scale for hardness. Reheat furnace to a uniform 700°F.	—	—	—	—

10.	Replace specimen into furnace with tongs. Allow two hours for specimen to soak.	—	—	—	—
11.	Remove specimen from furnace with tongs. Recheck it on Rockwell C scale for hardness. (There should be a noticeable decrease in the hardness reading after tempering.)	—	—	—	—
12.	Identify specimens, recording all hardness readings. Turn in to instructor for evaluation.	—	—	—	—
13.	Clean up area and return tools and materials.	—	—	—	—
	Average of above evaluations*	—	—	—	—

*This average is the student's final evaluation for competency F5: Perform heat treatment process.

MODULE: BENCH WORK AND MATERIAL SCIENCE

UNIT XI: TESTING AND HARDENING MATERIALS

UNIT TEST

Identify carbon content of steels from the SAE/AISI numbering systems.

____	1.	SAE-4340	a. .40%/1%
____	2.	SAE-1095	b. .16%/1%
____	3.	SAE-30316	c. .95%/1%
____	4.	AISI-C 1140	d. .20%/1%
____	5.	AISI-C 1020	e. .50%/2%
____	6.	AISI-E 2512	ab. .12%/1%
			ac. .40%/1%

Select the option which best answers the question or completes the statement.

____ 7. Which of the following factors do <u>not</u> affect cutting speeds and tool-bit geometry?

a. Material ductility
b. Material toughness
c. Material hardness
d. Material machinability
e. All of the above

____ 8. Which test identifies a material's hardness using a carbide ball (B scale) or a cone-shaped diamond penetrator (C scale)?

a. Spark
b. File
c. Rockwell
d. Brinell
e. McDonnell

____ 9. Which test causes metal to display a particular pattern when held against a grinding wheel?

a. Spark
b. File
c. Rockwell
d. Brinell
e. McDonnell

____ 10. Which of the following uses a ball penetrator to create an impression on metal? (The diameter of the impression is then measured and converted mathematically.)

a. Spark test
b. File test
c. Rockwell test
d. Brinell test
e. McDonnell test

Match the following terms and definitions related to heat treating.

____ 11. Property a material exhibits to become harder when heated and quenched above its critical temperature

____ 12. Property of an alloy composition or particular heat treatment to relieve hardness in a material

____ 13. Temperature at which a material changes from one phase to another to allow for hardening, tempering, stress relief, etc.

____ 14. Use of a medium (air, oil, water, brine, etc.) to cool a heated material to a prescribed temperature

____ 15. Important requirement in the heat treatment of carbon steels (High carbon equals increase in hardness; low carbon equals decrease in hardness.)

____ 16. Visible (under microscope) method of identifying material composition, heat treatments and phase changes in a given material

____ 17. Important requirement in selecting steels or nonferrous materials for heat treatment and mechanical properties

____ 18. Material's failure or fracture under torsion, vibration, bending, etc.

____ 19. Ability of a material to resist surface oxidation or rusting

____ 20. Change in shape or physical appearance of a material when it is loaded beyond its elastic limit or heated to extreme temperatures

____ 21. Property of a material to increase in volume during heating

____ 22. Ability of a material to withstand repeated shock loads without failure

____ 23. Material's ability to withstand a maximum load per cross-sectional area under a tension load; usually measured in pounds per square inch (psi).

____ 24. Internal stress built up in a material after rolling, hammering, bending, forging, etc., due to heating, cooling and mechanical working

a. Alloy content
b. Carbon content
c. Corrosion resistance
d. Critical temperature
e. Deformation
ab. Expansion
ac. Fatigue
ad. Grain structure
ae. Hardening
bc. Quenching
bd. Shock resistance
be. Softening
cd. Tensile strength
ce. Toughness
de. Work harden

25. List five safety precautions for heat treatment.

a.

b.

c.

d.

e.

ANSWERS TO UNIT TEST

1.	a or ac	(F3)	13.	d	(F5)
2.	c	(F3)	14.	bc	(F5)
3.	b	(F3)	15.	b	(F5)
4.	a or ac	(F3)	16.	ad	(F5)
5.	d	(F3)	17.	a	(F5)
6.	ab	(F3)	18.	ac	(F5)
7.	a	(F2)	19.	c	(F5)
8.	c	(F6)	20.	e	(F5)
9.	a	(F6)	21.	ab	(F5)
10.	d	(F6)	22.	bd	(F5)
11.	ae	(F5)	23.	cd	(F5)
12.	be	(F5)	24.	de	(F5)

25. Any five of the following: (F5)

a. Always wear goggles or a face shield to protect face and eyes while working with heated materials.
b. Always wear an apron, gloves and protective shoes to prevent burns from heated materials.
c. Exercise proper demonstrated procedure in lighting gas furnaces.
d. Always start air flow to gas furnace before turning on gas.
e. If furnace fails to light, clear fumes with air flow before relighting.
f. Know the off and on positions of the gas valve.
g. Shut off electrical circuit before inserting or removing material from an electrical furnace.
h. Use proper size and type of tongs to remove and insert material into a heated furnace.
i. Make sure that containers are sturdy and large enough to support material.
j. Use large enough quench tank to prevent overheating of the quenching medium.
k. Always dry tongs and ladles before using them in a salt-bath solution.